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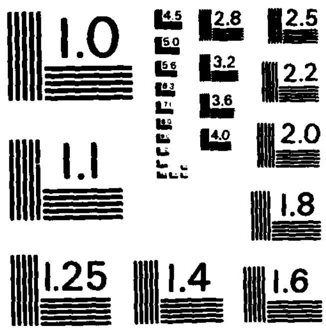

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Effect of Various Wave Conditions on Dynamic Hull Girder Loadings

Hoffman Maritime Consultants Inc.

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Final Report

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16. Abstract

The objective of this study was to determine the effect of various wave conditions on Dynamic Hull Girder Loadings, providing a complete documentation of the assumptions required for these analyses. By varying the wave data base, i.e. wave height statistics and wave spectural shape, as the basis for predicting the short term trends and long team responses of several different hull forms, the effect of such a variation on design requirements derived through this process can be gauged. The resulting comparison of long term responses will determine the significance of the wave data used.

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I. INTRODUCTION

I.1 Objective

The objective of this study is to determine the effect of various wave conditions on dynamic hull girder loadings, providing a complete documentation of the assumptions required for these analyses. By varying the wave data base, i.e. wave height statistics and wave spectral shape, as the basis for predicting the short term trends and long term responses of several different hull forms, the effect of such a variation on design requirements derived through this process can be gauged. The resulting comparison of long term responses will determine the significance of the wave data used.

I.2 Summary

Routings were selected from the North Atlantic and North Pacific, based on directional wave spectra obtained from the Spectral Ocean Wave Model (SOWM) hindcast data set. The routes were compared based on spectral properties and exceedance data. Other sources of spectral data included Station INDIA measured spectra and ISSC theoretical spectra. Other sources of exceedance statistics included observed wave heights, as tabulated by Hogben and Lumb, and measured wave heights obtained at Station INDIA and Station PAPA.

Response amplitude operators were prepared for midship vertical bending moment, vertical shearing forces, roll, and vertical and lateral accelerations for the following vessels: an SL-7 containership, a VLCC, an 87,000 DWT tanker, and a 490' general cargo ship. In addition, the probability of occurrence of deck wetness (shipping of water) was also evaluated for various freeboards.

After wave spectral data and RAOs were prepared, long term design values were calculated in order to study the effect of variation in spectral shape on long term analysis. For the different vessels, responses were compared for the various hindcast spectra. In addition, systematic comparisons of results obtained for each ship were performed by varying spectra (hindcast, Station INDIA measured, and ISSC two-parameter) and exceedance (hindcast, measured, and observed). This analysis illustrates the effect of combining the various spectral representatives with each of the available exceedance data sets.

The long term values thus obtained were then compared to the design requirement values for bending moment as specified by the American Bureau of Shipping "Rules for Building and Classing Steel Vessels", Lloyd's Register of Shipping "Rules and Regulations for the Construction and Classification of Steel Ships" and Det Norske Veritas "Rules for the Construction and Classification of Steel Ships."

In Section I of this report, the objective is stated, the report is summarized, and the conclusions of the study are listed.

Section II of the report deals with routings and spectral families. It is subdivided into sections which deal with route selection, types of data sources and descriptions of each, wave exceedance statistics, and definition and comparison of spectral families.

Section III deals with vessel response characteristics and is subdivided into brief descriptions of the vessels employed, their weight distributions and static shear forces and bending moments, description by hydrodynamic properties and response amplitude operators.

Shipping of water is discussed in Section IV, which describes the method of analysis of the occurrences of deck wetness, minimum freeboard requirements as defined by the Load Line Convention for each ship involved in the study, and a summary of results and conclusions.

Section V deals with the extreme bending moment predictions, based on long term statistical extrapolation. In this section comparisons are made which describe sensitivity of long term predictions to spectral shape, and the effect of varying data sources on these predictions. Long term predictions are then compared with classification society rules.

Section VI consists of an evaluation of vertical accelerations obtained from the method specified by the U.S. Coast Guard. Estimates are compared to the values predicted by the ship motion programs and extreme value theory. A list of References is included in Section VII.

Hydrostatic properties and weight data for each of the four vessels is summarized in Attachment A, and tables summarizing the results are provided in Attachment B. A complete set of computer printouts is contained in a set of separately bound Appendices.

I.3 Conclusions

On the basis of this analysis, it can be concluded that:

1. Wave induced bending moments estimated using hindcast, measured and observed data are generally larger than that obtained from the classification society rules when dealing with vessels over 700 feet in length and smaller when dealing with vessels of about 500 feet long.

2. Wave induced bending moments obtained using hindcast data range from 42% to 94% greater than those obtained from classification society rules for the larger vessels and are 12% lower for the smaller vessel.

3. A change in ship's heading will affect vertical bending moments much more than varying speed. Most wave induced bending moments in this report were obtained assuming an equal prcbability of all headings occurring. Of course, in reality a ship's operator can respond to sea conditions. Therefore, calculations were done for the SL-7 varying speed and heading, and it was determined that a change in ship's heading will affect vertical bending moment to a much greater extent than varying speed.

4. U.S. Coast Guard estimates of vertical acceleration tend to overestimate vertical acceleration in the case of tankers (wider, fuller vessels) and tend to under estimate vertical accelerations for finer ships (general cargo and container ships).

5. Deck wetness characteristics can be improved greatly through the addition of a forecastle by the designer. This is especially true of smaller dry cargo ships. Also, the proportion of the minimum freeboard by which the actual freeboard must be increased, in order to avoid deck wetness, is approximately the same for different types of ships.

II. ROUTINGS AND SPECTRAL FAMILIES

II.1 Route Selection

Classification society rules regarding required section modulus should be valid for a ship operating anywhere in the world. Therefore, any study which attempts to examine and offer improvements on the basis for such requirements should utilize data which contains information from various parts of the oceans, preferably from widely used trade routes.

A list of frequently travelled trade routes would include at least one route in each of the North Atlantic and the North Pacific. Furthermore, the North Atlantic can be divided into two major routes: a direct mid-Atlantic route (New York to English Channel) and a more northerly great circle route (New York to Baltic). These three routes cumulatively would include the points in the world's oceans which a merchant ship is most likely to cross as well as some of the more severe areas which a vessel can expect to encounter. The three routes used in this particular study are shown in Figure II.1. By using data associated with these routes, a logical and unbiased study can be made of the types of sea conditions a vessel can expect to encounter.

II.2 Data Sources

Available sources of wave data include observations, measurements and hindcasts. Observations generally consist of log entries made by the ship's deck officer, which may include estimates of sea and swell, height, direction, wind force, etc. Measurements consist of recordings of wave surface time history through the use of instrumentation from which wave height, period, spectra, etc. can be derived. Hindcast directional spectra specify the distribution of wave energy with respect to frequency and direction, based on wind fields and wave propagation theory. Each of these data sources, along with their advantages and short comings, is described in the remainder of this section.

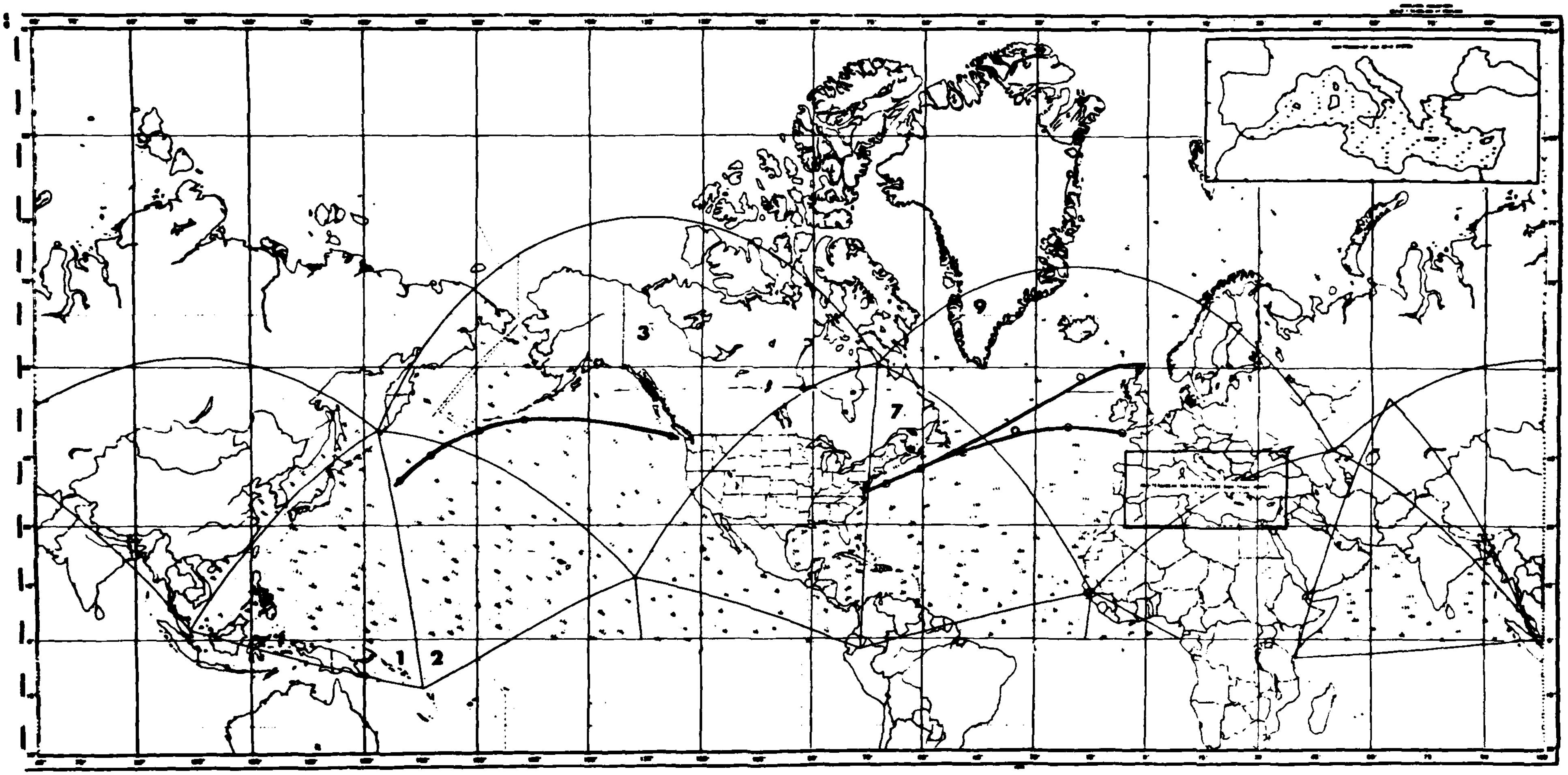

Figure II.1: SPECTRAL OCEAN WAVE MODEL (SOWM) GRID POINTS

NOTE: Small numbers in each triangle are grid point numbers; large numbers identify subprojection.

——— indicates routings considered

O indicates grid points defining each route

II.2.1 Observation

The simplest method of gathering wave data is through observation. Extensive coverage of observed wave heights exists for commonly traveled trade routes because a large number of observations come from merchant vessels as well as weather ships and some voluntary observing ships.

Wave observation statistics are a collection of subjective judgements made by many different observers. The accuracy of the observations varies greatly from observer to observer and, not surprisingly, observed data is by far the most biased. The most obvious bias is toward fair weather because merchant ships generally try to avoid bad weather. Thus, the percent occurrence of the larger wave height groups is highly underestimated. Additional bias stems from the fact that observers often fail to code wave observations, if wave conditions are calm, thus reducing the percentage of reported fair weather. Also, because of the difference in ship behavior, observers tend to underestimate following seas and overestimate head seas. These factors are extremely difficult to quantify and cannot be compensated for adequately.

It is not possible to develop reliable spectral data from wave observations because the periodic motion of the ship and the random nature of the waves make the timing of wave crests difficult, which results in poor estimates of wave periods. Therefore, it is impossible to quantify spectral energy (a function of amplitude) versus wave frequency by observation. Additionally, for values of wave height above 30 feet (10 meters) or below 5 feet (2 meters), the observer's ability to estimate adequately is doubtful, in the former case due to conditions aboard ship and in the latter case due to cross seas, swell, etc.

II.2.2 Measurement

Although more accurate than observed data, wave measurements are much more limited in both quantity and location. Measured wave data has been accumulated from weather ships, buoys and platforms. The extent and reliability is documented fully in Ship Structures Committee Report SSC-268 [1]. The measured data used in this study is from Station INDIA, a point in the North Atlantic analyzed by Hoffman [9].

Waves are measured and analyzed in several different ways using a number of instruments. The number of measuring instruments is large, yet each has been used in a limited quantity. Few have been widely used for a long period of time. Analysis of new data can vary from determining spectral parameters by visual analysis of peaks, trough, maxima, minima and number of zero crossings to Fourier transform of the auto-correlation function or by Fast Fourier analysis.

It is difficult to draw conclusions about "typical" or mean spectra for a location without having a large sample. Such large samples of spectra are available for few locations, among them Station INDIA. The measurement of the directional wave spectrum, which specifies the energy as a function of both direction and frequency, requires sophisticated instrumentation and data processing. The number of such spectra is limited to a handful.

II.2.3 Hindcast Data

Because of the limitations of observed data and the limited quantity of measured data, the best source of wave data is hindcasting which utilizes wave generation and propagation models. One such hindcast model is the Spectral Ocean Wave Model (SOWM), operational at the Fleet Numerical Oceanography Center (FNOC) since 1974. It has been used to produce spectra and exceedances for a 20-year ocean wave climatology.

The theories upon which the SOWM is based assume a short-crested gaussian sea surface as a model. This requires that the waves can be described by either a frequency and direction spectrum or by a vector wave number spectrum. One of the concepts in the SOWM is that a fully developed, wind-generated sea can be defined by a wave spectrum which is independent of fetch and duration, and is a function of the wind speed only. Winds are defined accurately by a method which predicts wind as a function of height above the ocean.

Thus, a fully developed sea can be obtained from an input of barometric pressure distributions after the effect of the initial conditions has diminished. This approach is not without weaknesses, such as the inability to predict the occurrences of episodic events (tsunami, etc.). Such events, however, are not significant for design purposes because these do not occur often enough to be of consequence.

For wave forecasts, the SOWM is reinitialized every six hours by using six hour old spectral data and computing how the spectra changed on the basis of wind fields computed from the available synoptic weather reports. Then, wave forecasts are made by means of forecasted wind fields. Each wave forecast depends upon both the accuracy of the past wind fields used to reinitialize the model and on the accuracy of the wind field forecasts.

The previously mentioned SOWM grid is an icosahedron (solid bounded by 20 equilateral triangle). Each triangular subprojection has 25 grid points, equally spaced on the gnomonic projection, along each side. There are a total of 325 grid points in the triangle, of which 72 are on the edges. A great circle property is indicated by the fact that waves can travel to a given grid point along a great circle path from any one of the six surrounding grid points, thus accounting for six of the 12 directional bands in the model. The other six direction bands have directions of travel halfway between those for each of the primary directions.

Hindcasting is the best method for estimating wave data because it represents a greater sampling at more locations than measured data (which is usually only close to the continental shelf) and is far better at predicting phenomena such as swell than either observation or measurement. Extensive documentation and a discussion of verification of the SOWM has been prepared by Pierson [2].

II.3 Wave Statistics

Exceedance data specifies the probability of waves exceeding a particular height. This concept can be expressed in the form of percent occurrence of wave height groups (0-3 feet, 3-6 feet, 6-9 feet, etc.). Expressing the percent occurrence of wave height groups gives an indication of the severity of a particular point, which is significant in long term analysis.

Exceedance statistics can be derived from an analysis of wave heights at a particular location over any suitable interval of time; the data need not be continuous, or even regularly spaced, as long as enough independent observations (or measurements

or hindcasts, etc.) are available to characterize the wave height distribution. Exceedance data is frequently developed as a basis for extrapolating to "extreme storm" design conditions, or for evaluating cumulative processes such as fatigue.

The locations considered in this evaluation include a North Atlantic route, a mid-Atlantic route, and a North Pacific route. The hindcast grid points associated with each route, and their corresponding latitude and longitude, are shown in Table II.1.

Table II.2 is a compilation of percent occurrences by wave height group for all hindcast grid points involved in this study as well as measured and observed data (measured data is Station INDIA; observed is Hogben and Lumb). The numbers listed are simply the percent occurrence of that particular wave height group. These percentages are an important measure of the severity of each point.

More realistic exceedance levels, closer to those which would be encountered, can be obtained by averaging percent occurrences by wave height groups for all grid points contained in a particular route. Such statistics take into account the fact that a ship will not remain at one point in the ocean. Percent occurrence of water height groups for the three routes, as well as for measured and observed data, are compiled in the bottom half of Table II.2.

TABLE II.1

LATITUDE AND LONGITUDE OF SOWM GRID POINTS

	NORTH ATLANTIC	LATITUDE	LONGITUDE
1.	G272S7	39.04 N	71.52 W
2.	G275S7	42.85 N	60.90 W
3.	G278S7	45.58 N	49.00 W
4.	G187S9	49.95 N	35.40 W
5.	G128S9	58.58 N	18.17 W
6.	G105S9	59.92 N	2.29 W
	MID ATLANTIC		
1.	G272S7	39.04 N	71.52 W
2.	G275S7	42.85 N	60.90 W
3.	G278S7	45.58 N	49.00 W
4.	G187S9	49.95 N	35.40 W
7.	G184S9	50.58 N	21.47 W
8.	G181S9	49.44 N	6.94 W
	NORTH PACIFIC		
9.	G216S3	49.01 N	128.35 W
10.	G102S3	51.81 N	167.25 W
11.	G056S3	50.03 N	178.91 W
12.	G045S2	45.82 N	168.21 E
13.	G114S2	40.30 N	159.59 E

Note the grid point naming convention (refer to Figure II.1) Gxxx Sy, where xxx is the grid point number, and y is the subprojection number.

TABLE II.2

PROBABILITY OF OCCURRENCE OF WAVE HEIGHT GROUPS

LOCATION	0-3	3-6	6-9	9-12	12-16	16-21	21-27	27-32	32-40	40-50	50-60
ATLANTIC:											
G272S7	.4443	.2673	.1503	.0751	.0345	.0152	.0063	.0036	.0014	.0012	.0000
G275S7	.2288	.2755	.2034	.1262	.0900	.0193	.0479	.0040	.0010	.0001	.0000
G278S7	.0970	.2170	.2100	.1610	.1380	.1010	.0520	.0160	.0070	.0010	.0000
G187S9	.0734	.1700	.1911	.1677	.1555	.1191	.0745	.0248	.0168	.0021	.0005
NORTH ATLANTIC:											
G128S9	.0834	.1664	.1817	.1625	.1559	.1224	.0727	.0784	.0191	.0027	.0006
G105S9	.1853	.2376	.1988	.1437	.1137	.0742	.0359	.0074	.0301	.0000	
MID ATLANTIC:											
G184S9	.0933	.1860	.2040	.1627	.1463	.1017	.0613	.0218	.0156	.0028	.0003
G181S9	.2075	.2788	.1964	.1207	.0897	.0571	.0308	.0119	.0061	.0005	.0006
PACIFIC:											
G216S2	.1370	.2163	.1958	.1374	.1285	.0981	.0558	.0157	.0100	.0006	
G102S3	.0626	.1632	.1972	.1673	.1747	.1306	.0660	.0215	.0121	.0080	.0050
G056S3	.0776	.1698	.1863	.1677	.1684	.1202	.0637	.0234	.0159	.0026	.0003
G045S2	.0777	.1608	.1696	.1537	.1633	.1358	.0854	.0300	.0168	.0023	.0006
G114S2	.1198	.2195	.1902	.1599	.1462	.0941	.0431	.0142	.0069	.0002	
AVERAGES:											
NORTH ATLANTIC	.1854	.2223	.1892	.1393	.1146	.1027	.0434	.0140	.0125	.0012	.0001
MID ATLANTIC	.1907	.2324	.1925	.1355	.1090	.0736	.0407	.0136	.0080	.0002	
NORTH PACIFIC	.0949	.1859	.1878	.1572	.1562	.1157	.0627	.0209	.0123	.0011	
STATION INDIA	.0875	.2375	.3070	.2035	.0690	.0495	.0269	.0170	.0025	.0005	
HOGBEN & LUMB	.1121	.3652	.2591	.1369	.0754	.0223	.0212	.0074	.00012	.00002	

II.4 Spectral Families

The frequency distribution of wave energy in a seaway is defined by the wave energy spectrum. Several properties related to the moments of the spectrum are commonly used to quantify its nature. The area under the wave spectrum (zeroth moment) gives rise to the definition of significant wave height; the first moment is used to define the mean period. Higher moments of the spectrum are used to define such quantities as broadness, skewness and flatness, defined in Table II.3. However, while it is possible to derive a multitude of parameters from the spectral shape, the parameters themselves do not uniquely define the shape.

Figure II.2 illustrates several wave spectra, each having very nearly the same significant wave height and period. Yet, even when plotted non-dimensionally, the spectral shape varies considerably. The theoretical spectrum shown in Figure II.2 shows how inadequate a mathematical relationship can be in characterizing spectral shape.

Mathematical spectra fail to simulate the "double-peak" of spectral energy vs. frequency. Mathematical spectral formulations, such as the Pierson-Moskowitz, modified Bretschneider, etc. represent, at best, average conditions for open ocean locations. Even the fetch-limited spectral formulations, such as the JONSWAP spectra, do not adequately represent the bi-modal characteristics of actual wave spectra. The variability in mathematical spectra is due to variation in period only, not in shape, directionality, degree of development of the sea, etc. This variation in shape is due to the random nature of the sea; furthermore, the response of a vessel to the sea is similarly varied. In order to estimate the distribution of response amplitudes that may occur in a particular sea condition, it is necessary to incorporate the variability of spectral shape in the wave spectral representation.

In concept, the responses that may result from waves within a range of, say, 6-9 feet significant height would be best determined by computing (or model testing) using all available wave spectra in that range of wave heights (for the intended location). As a practical matter, this could entail dozens, hundreds, or even thousands of spectra.

TABLE II.3

DEFINITION OF WAVE SPECTRAL PROPERTIES

$H_{1/3}$	significant wave height $= 4\sqrt{m_o}$	
$T(1)$	mean average period $= 2\pi\, m_o/m_1$	
$T(-1)$	energy average period $= 2\pi\,(m_{-1}/m_o)$	
$T(2)$	zero-crossing period $= 2\pi\sqrt{m_o/m_2}$	
$T(4)$	average apparent period $= 2\pi\,(m_2/m_4)^{1/2}$	
$HC(1/3)$	$H_{1/3} \times D$; significant wave height, corrected from broadness	
B	$m_3/m_2^{3/2}$	Skewness
ϵ	$\sqrt{1 - m_2^2/m_o\, m_4}$	spectral width parameter
D	$\sqrt{1 - \epsilon^2/2}$	broadness correction
ω_o	peak spectral frequency	
$H_{1/3}/\lambda_o$	wave slope ; λ_o = wave slope	

Definition of Spectral Moments, m;

$m(-1)$

m_o

$$\left.\begin{array}{l} m_1 \\ m_2 \\ m_3 \end{array}\right\} \quad m_n = \int_0^{\infty} \omega^n \; S_\zeta(\omega) \cdot d\omega$$

m_4

$S_\zeta(\omega)$ wave spectral energy density

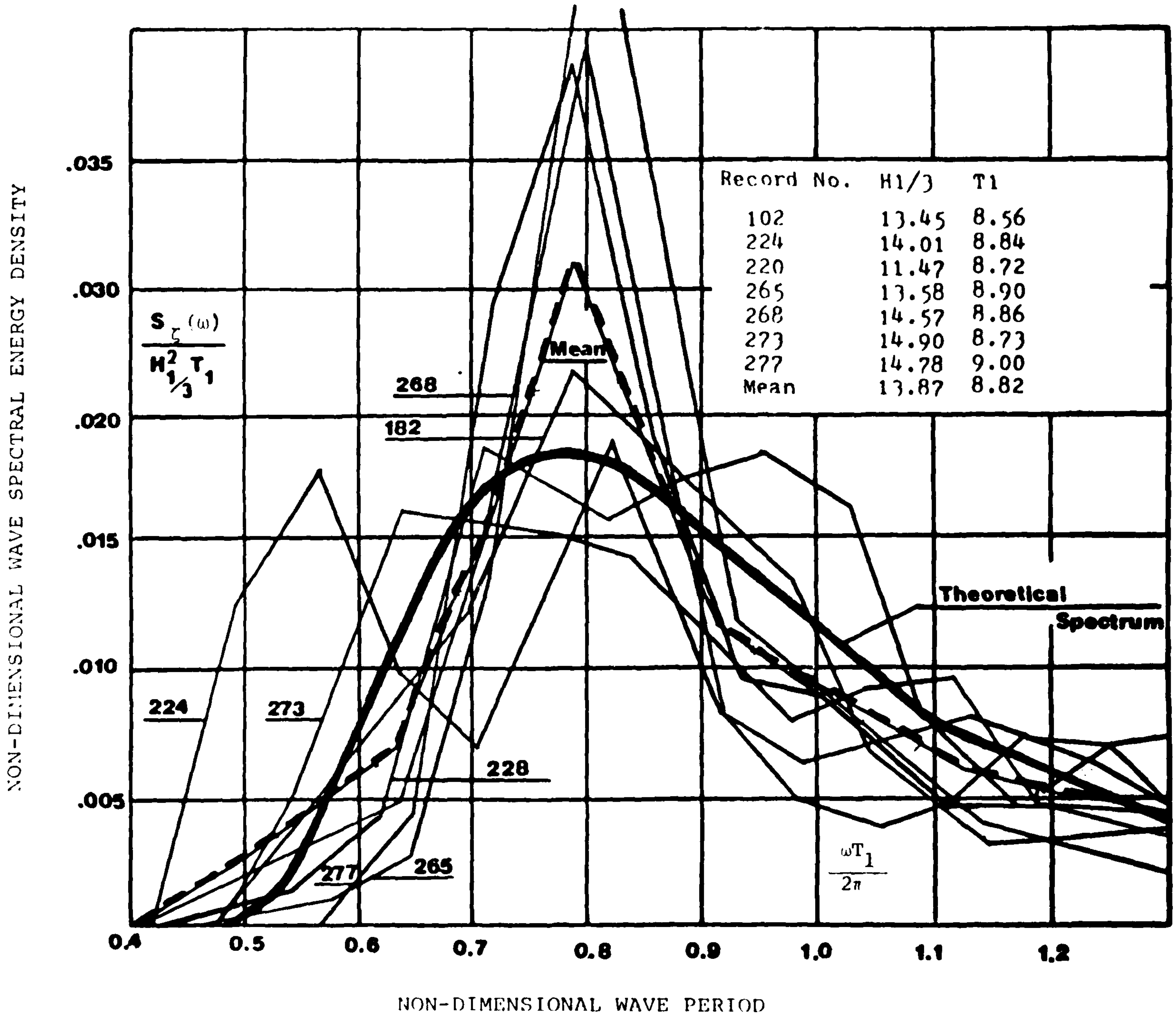

Figure II.2: COMPARISON OF SPECTRAL SHAPE VARIATION

A practical approach involves the use of a small number of spectra, obtained from measurement or hindcast, whose properties match the properties of the total sample of available spectra. As a minimum, spectra from 8-10 different "storm" (or calm) periods are required to quantify the variation in spectral shape that can occur within a single sea state. A typical family of spectra for one sea state is shown in Figure II.3. A wave spectral family would consist of 8-10 such groups, of 8 spectra per group, covering the full range of wave heights occurring at the site. Figure II.4 is a listing of spectral properties for a typical wave height group.

To represent the variations in wave spectral shape, an entire sample of thousands of wave spectra are "grouped" according to significant wave height. The properties of all spectra within each wave height range (0-3 feet, 3-6 feet, 6-9 feet, etc.) were calculated; then, a Monte Carlo technique was employed to select several groups of spectra exhibiting properties comparable to the total population within each wave height range. The resulting sample of spectra, covering the full range of wave heights occurring at the site, is referred to as a "spectral family."

The basis for long term ship response prediction is that when the spectra are combined with the vessel's response amplitude operators (RAOs), the envelope curve of the resulting response is Rayleigh distributed. From this a RMS response is determined which follows a normal distribution by wave height group. The responses are thus "Rayleigh-Normal" distributed. This concept has been covered extensively by Band [6]. RAOs and responses are discussed in greater detail in the next section.

A comparison of spectra used in this study appears in Table II.4, which is a comparison of wave height groups vs. period for a series of hindcast data points as well as Station INDIA measured data. The difference is significant in that Station INDIA possesses greater periods for smaller wave height groups and shorter periods for longer wave height groups. Because these short periods are, in general, closer to the resonant periods of most ships, it can be expected that responses due to spectral shape will be more severe for the measured data even though exceedance levels tend to indicate otherwise (see Figure II.5). Figure II.6 is a comparison of exceedance levels for two hindcast points (one Atlantic and one Pacific).

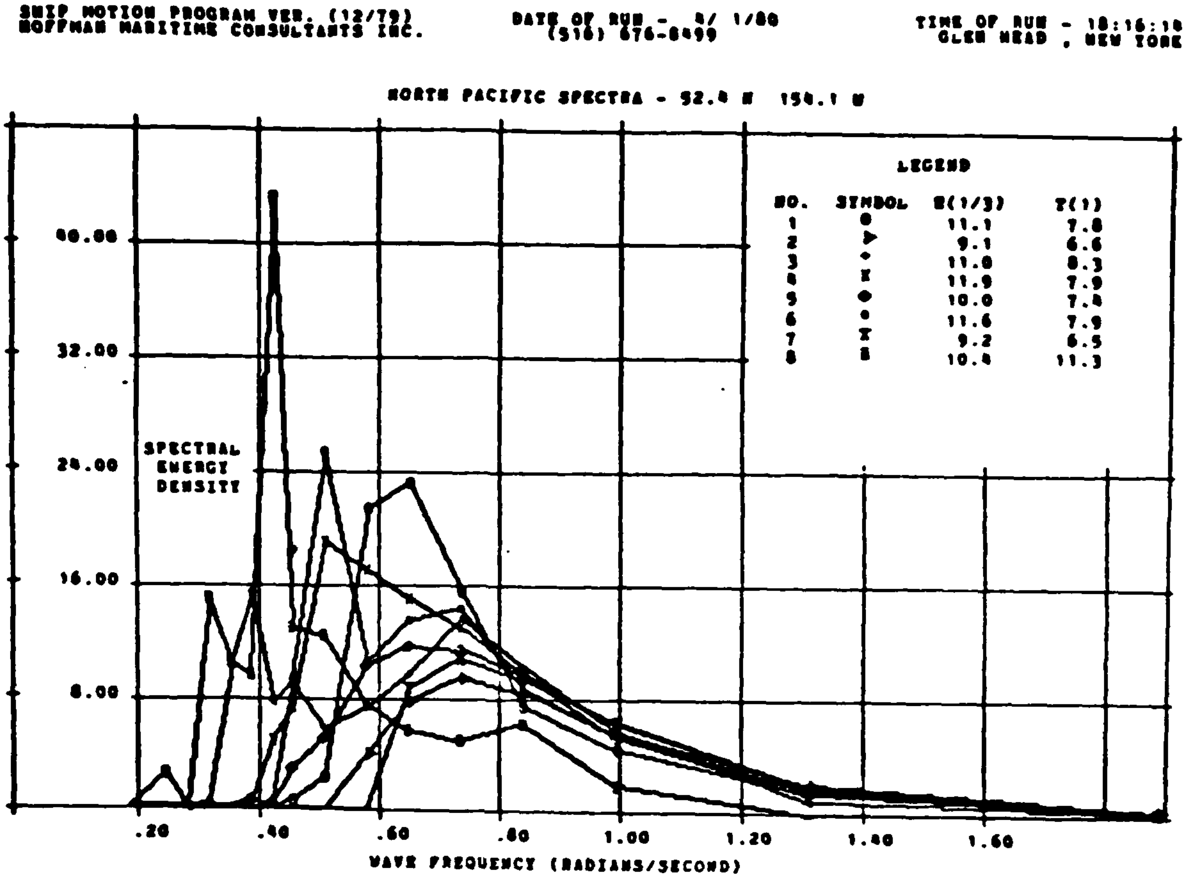

Figure II.3: TYPICAL SPECTRAL FAMILY

H(1/3)= 10.59 AND STD DEV OF ORDINATES= 3.7901

PROPERTY	AVERAGE	SPECTRA NUMBER 1	2	3	4	5	6	7	8
H(1/3)	10.600	11.107	9.087	11.004	11.917	10.057	11.575	9.260	10.439
PER T1	7.833	7.754	6.555	8.250	7.833	7.378	7.900	6.522	11.313
PER T-1	8.936	8.445	7.109	9.543	8.776	8.081	8.850	6.987	12.848
PER T2	7.343	7.355	6.279	7.712	7.358	7.020	7.413	6.280	10.561
PER T4	5.792	5.868	5.325	6.071	5.787	5.754	5.793	5.401	8.309
MOM M-1	9.988	10.363	5.840	11.495	12.398	8.131	11.794	5.959	13.926
MOM MO	7.023	7.710	5.161	7.568	8.877	6.322	8.374	5.359	6.810
MOM M1	5.633	6.248	4.947	5.764	7.120	5.384	6.660	5.162	3.782
MOM M2	5.142	5.626	5.168	5.023	6.473	5.065	6.016	5.364	2.401
MOM M3	5.293	5.695	5.873	4.935	6.657	5.274	6.171	6.019	1.726
MOM M4	6.050	6.451	7.196	5.381	7.630	6.040	7.078	7.258	1.373
HC(1/3)	9.547	10.047	8.425	9.903	10.721	9.195	10.388	8.636	9.385
SKEWNES	0.454	0.427	0.500	0.438	0.404	0.463	0.418	0.485	0.464
BROADNS	0.615	0.603	0.530	0.617	0.617	0.573	0.624	0.510	0.619
FLATNES	0.229	0.204	0.269	0.213	0.182	0.235	0.196	0.252	0.238
OMEGA	0.646	0.646	0.733	0.384	0.506	0.646	0.506	0.733	0.419
H/LAMDA	0.022	0.023	0.024	0.008	0.015	0.021	0.015	0.025	0.009

Figure II.4: SPECTRAL PROPERTIES FOR WAVE HEIGHT GROUP

TABLE II.4

PERIODS OF WAVE HEIGHT GROUPS FOR 13 GRID POINTS + STATION INDIA

LOCATION	0-3	3-6	6-9	9-12	12-16	16-21	21-27	27-32	32-40	40-50	50-60	60+
G045S2	6.8	6.7	7.1	7.8	8.5	9.4	10.3	11.2	12.2	13.6	14.4	
G056S3	6.5	6.6	7.3	7.7	8.6	9.6	10.4	11.4	12.5	14.0	14.6	
G102S3	6.7	6.8	7.4	7.8	8.6	9.8	10.5	11.4	12.5	13.9	15.1	
G105S9	6.3	6.2	6.9	7.6	8.4	9.3	10.4	11.5	12.4	13.9	14.5	
G114S2	6.7	6.9	7.2	7.9	8.5	9.4	10.3	11.2	12.2	13.5	14.4	
G128S9	6.7	6.8	7.9	7.7	8.5	9.4	10.5	11.4	12.4	13.9	14.9	16.0
G181S9	6.2	6.6	7.0	8.0	8.8	9.8	10.9	12.1	13.2	14.6	15.6	
G184S9	6.8	6.8	7.1	7.6	8.4	9.4	10.5	11.5	12.6	14.0	14.8	
G187S9	6.6	6.6	6.9	7.6	8.5	9.5	10.5	11.3	12.4	13.8	14.8	16.9
G216S3	6.9	7.2	7.8	8.2	8.9	9.7	10.6	11.4	12.6	13.7	14.6	
G272S7	6.0	5.9	6.5	7.4	8.2	9.7	10.7	12.1	13.6	14.0		
G275S7	6.5	6.3	6.7	7.4	8.4	9.1	10.2	11.0	11.9	13.6	13.8	
G278S7	6.5	6.6	7.0	7.6	8.2	9.3	10.1	11.2	12.1	13.2	13.8	
STATION INDIA	7.0	7.4	8.2	8.2	8.8	8.6	9.3	9.9	11.2	11.5		

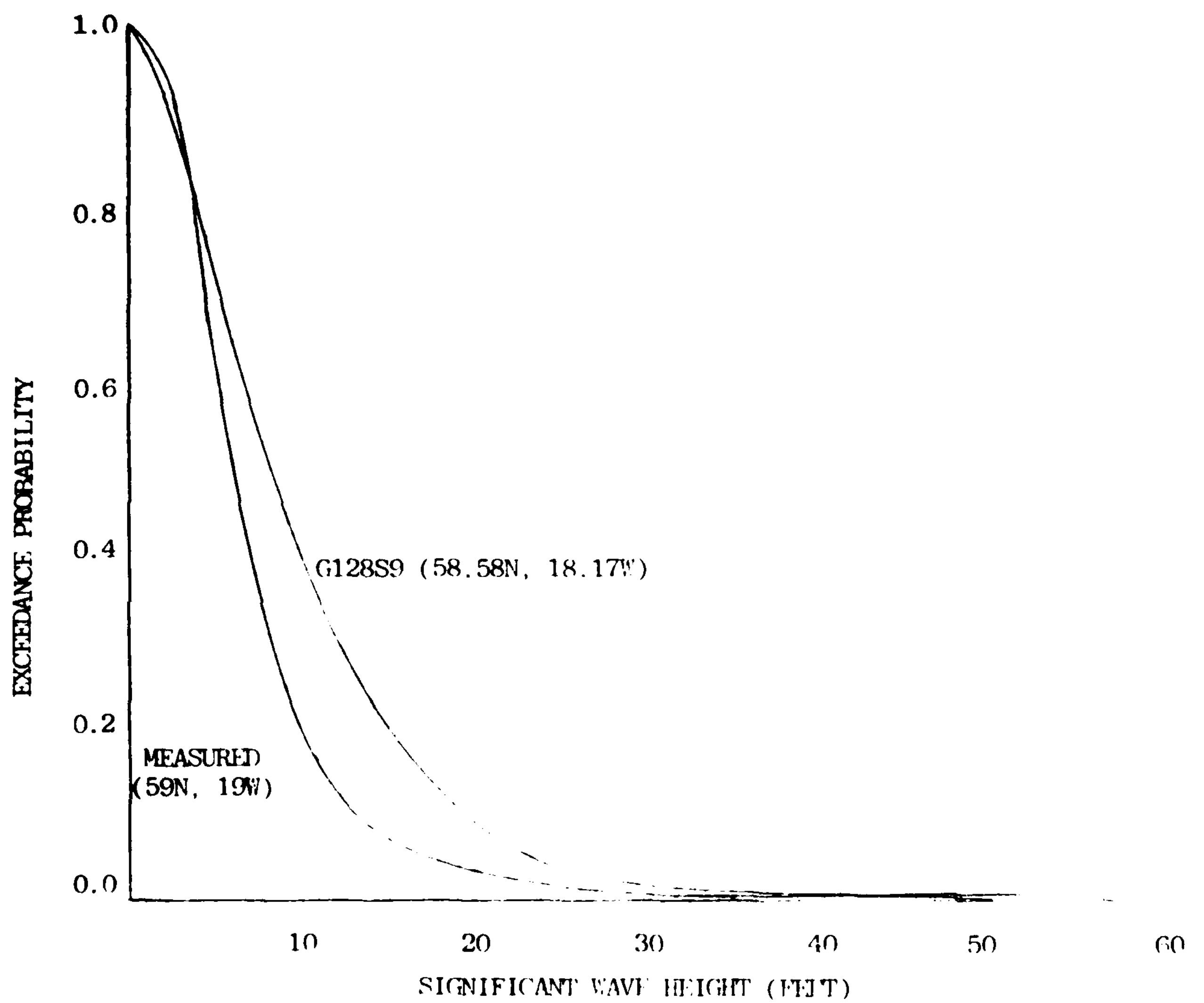

Figure II.5. COMPARISON OF EXCEEDANCE LEVELS, MEASURED (STATION INDIA) AND HINDCAST

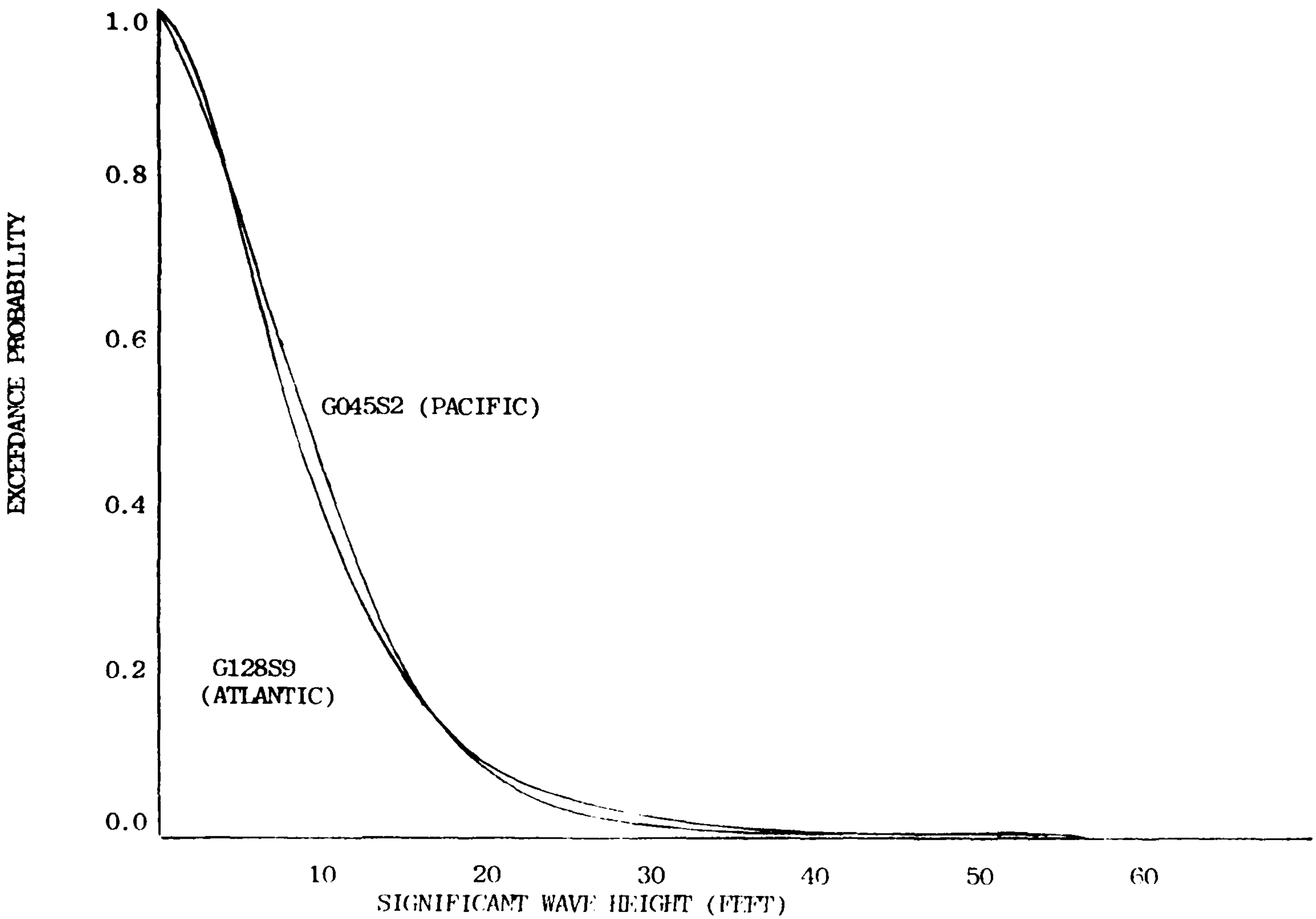

Figure II.G: COMPARISON OF EXCEEDANCE LEVELS FOR MOST SEVERE POINTS (HINDCAST) ATLANTIC & PACIFIC

III. VESSEL RESPONSE CHARACTERISTICS

Assessment of the response characteristics of a vessel as affected by environmental conditions requires two basic inputs:

A) Wave data, either mathematical, measured or hindcast, ideally in spectral format, as well as statistical exceedance (probability of occurrence of wave height groups), preferably covering several years of data, and

B) Vessel characteristics data, such as the geometry of the outer hull contour, and the longitudinal, transverse and vertical weight distributions. Other specific parameters also required, such as the displacement, center of gravity and initial stability parameters, can be evaluated from the above input data.

Additional input includes the specification of the responses required and the conditions at which they are to be calculated, a viscous damping correction factor to account for effects not accounted for by potential theory and various assumptions with regard to the operating scenario.

The vessel geometry is generally represented in terms of offsets describing the shape of the hull up to main deck. Two-dimensional hydrodynamic properties are determined from ship geometry, using either a multi-coefficient conformal mapping approach, or distribution of sources and sinks about transverse sections along the ships length. The three-dimensional hydrodynamic coefficients and wave excitation forces and moments are determined by integration over the length of the ship. The linear six degree of freedom coupled differential equations of motion are then solved to determine the response amplitude operators for a range of wave frequencies and headings. The procedure is outlined in the flow diagram shown in Figure III.1, and explained in greater detail in the remainder of this section.

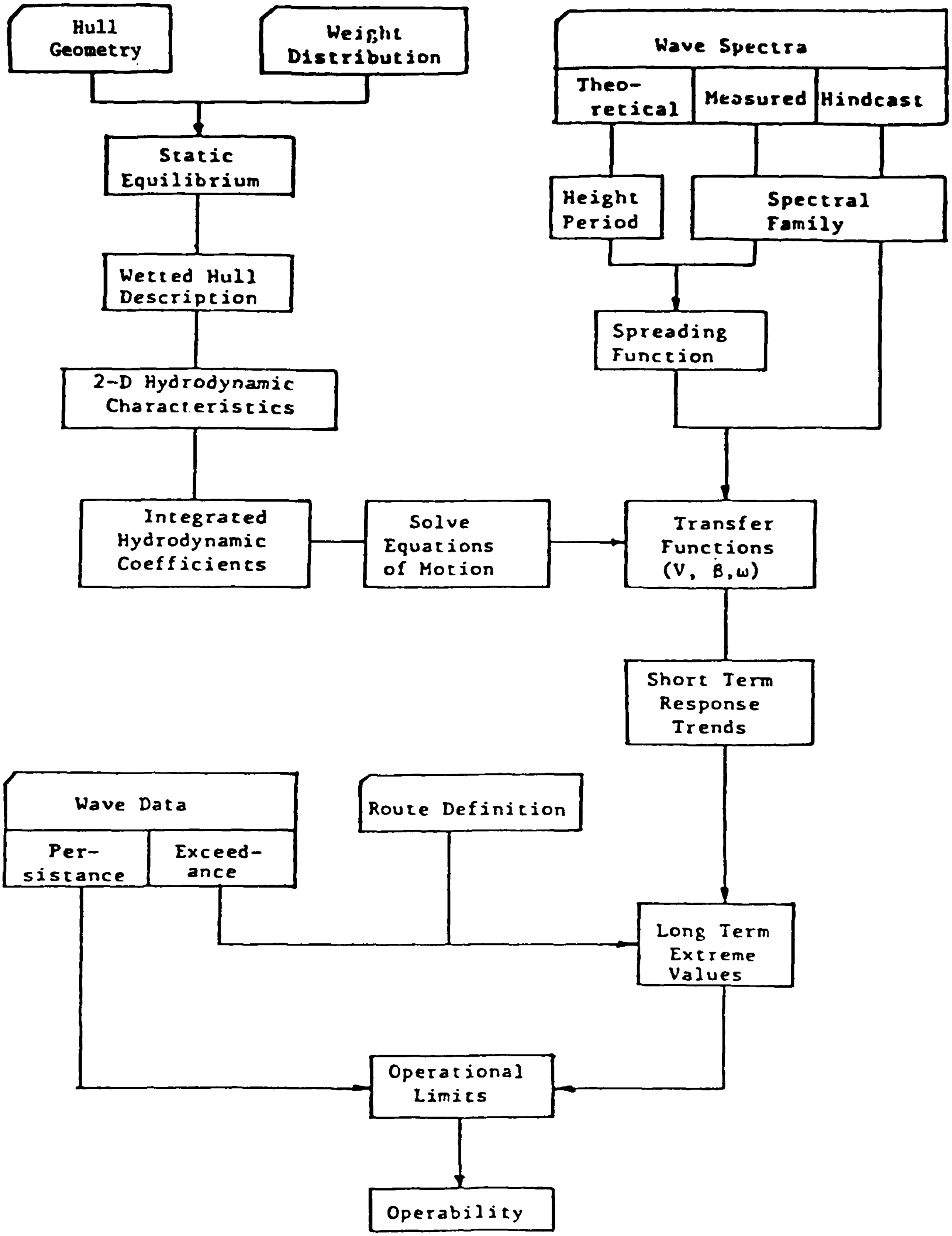

Figure III.1: OPERABILITY ANALYSIS SYSTEM DIAGRAM

III.1 Vessel Characteristics

The four vessels chosen for this study include the 30 knot SL-7 containership, a VLCC of 114,000 tons, an 87,000 DWT Tanker, and a general cargo ship of just under 500 feet. (See body plans, Figures III.2 - III.5). These vessels represent a wide variation in speed, displacement, length, and form coefficients. This can be seen in a listing of the general properties of the vessels (Table III.1).

TABLE III.1

	SL-7	VLCC	TANKER	GENERAL CARGO
DISPLACEMENT (L.TONS)	47,760.0	114,346.0	87,448.0	19,033.0
LENGTH (FT)	880.5	879.0	763.0	492.0
BEAM (FT)	105.0	127.7	125.0	75.3
DEPTH (FT)	64.0	66.8	54.5	43.5
DRAFT (FT)	32.75	43.56	40.12	31.65
BLOCK COEFFICIENT	.549	.816	.799	.568
PRISMATIC COEFFICIENT	.588	.826	.802	.613
MIDSHIP SECTION COEFFICIENT	.934	.987	.997	.927
SPEED (KNOTS)	30.0	16.0	16.5	16.0
PITCH PERIOD (SEC)	7.77	8.56	8.40	6.94
ROLL PERIOD (SEC)	26.58	12.75	11.015	17.23
ABS MIN. REQ. SECTION MODULUS ($IN^2 FT$)	103,304	144,200	100,481	18,744

III.2 Weight Distribution

Part of the input to describe the vessels is the longitudinal weight distribution. Weight distributions for the ships involved in this study are included on the following pages. The weight distribution consists of a series of weight blocks described by a block weight in long tons, and a block forward end, aft end and LCG in feet aft of the FP. The net result of the weight distribution is a summary weight in long tons (displacement) and a summary LCG in feet aft of the FP, as well as longitudinal gyradius. All weights are for the full load condition. Weight distributions are included in Attachment A along with tables of hydrostatics and still water shear forces and bending moments.

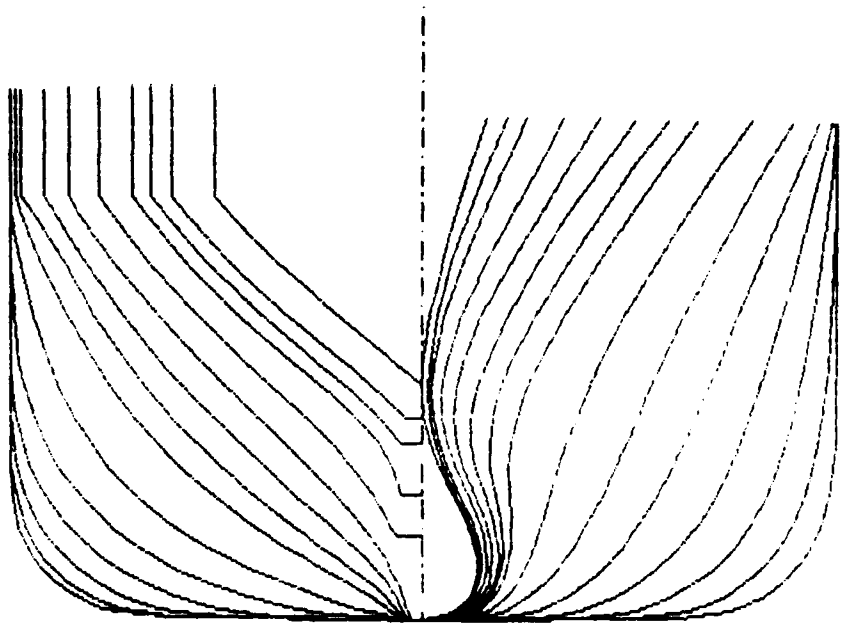

Figure III.2: SL-7 CONTAINERSHIP

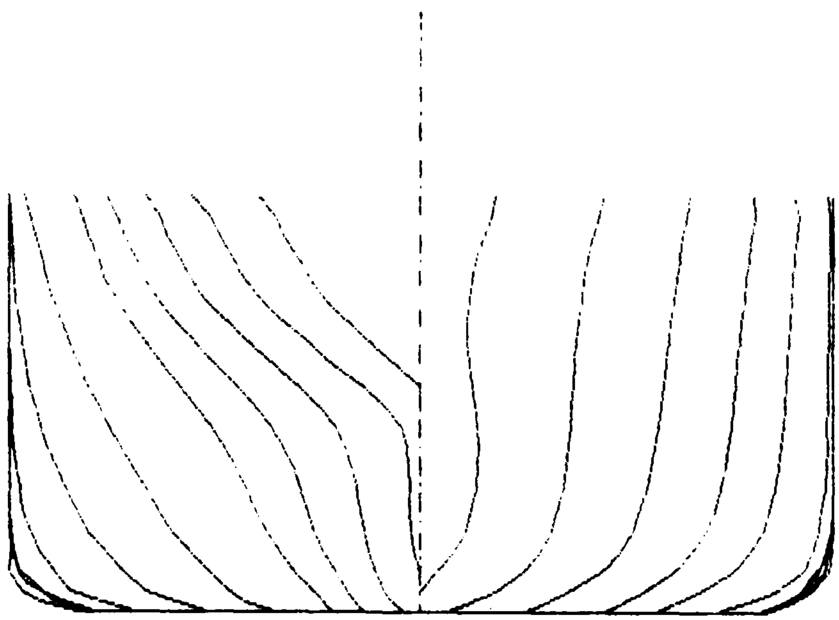

Figure III.3: VLCC

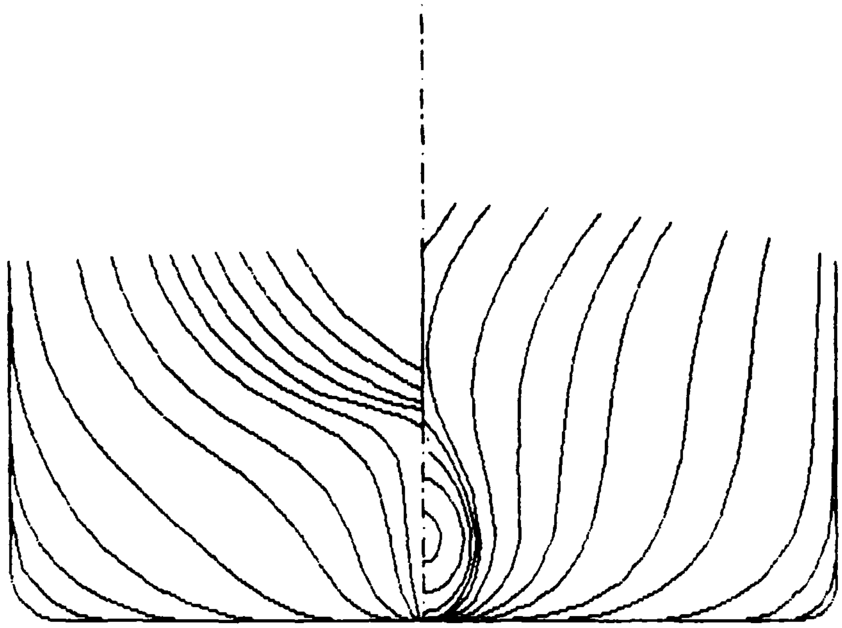

Figure III.4: 87,000 DWT Tanker

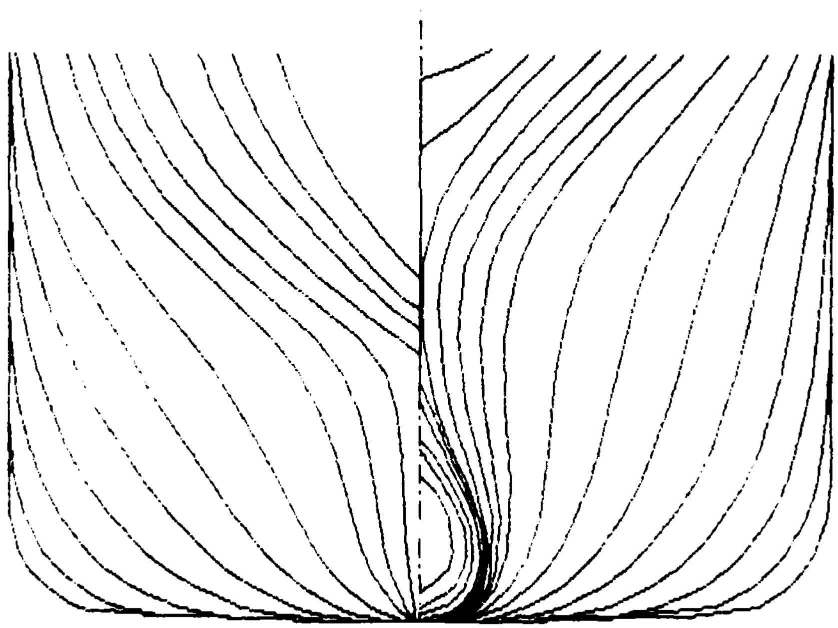

Figure III.5: General Cargo Ship

III.3 Hydrodynamic Properties

Due to the complexity of the three-dimensional shape of the hull, the calculations of the hydrodynamic characteristics due to vertical, lateral and angular oscillation about the free surface is not feasible and the characteristics of infinitely long cylinders having a cross section identical to that of the hull's transverse section is calculated instead. Each cylinder is defined in terms of its cross sectional area by means of offsets between keel and the waterline intersection. In order to determine the added mass and damping due to oscillation on the free surface, two techniques are available: conformal mapping and source sink distribution [11].

Depending on the sectional shape, either of the two methods may be preferable. For normal ship shape sections, the results are generally quite similar. A sample of the two-dimensional hydrodynamic coefficients computed for the SL-7 is shown in Table III.2. A more detailed description of the procedure is provided in the User's Manual for STATIC, the first part of the U.S.C.G. ship motion program.

TABLE III.2

SL-7 CONTAINERSHIP, FULL LOAD — STATION 44.025 FEET
TWO-DIMENSIONAL PROPERTIES -28 POINTS — DRAFT = 32.588 FEET

FREQ. PARAM.	A'_{33}	N'_{Z}	M_{S}	N_{S}	$M_{S.R}$	$N_{S.R}$	I_{R}	N_{R}
.00	.197	.001	1.759	-.000	24.97	-.00	386.6	-.0
.01	.169	.003	1.779	.000	25.28	.00	390.8	.0
.03	.155	.005	1.826	.001	25.91	.01	399.6	.2
.06	.146	.006	1.903	.004	26.97	.06	414.4	.9
.10	.141	.007	2.017	.016	28.55	.24	436.2	3.6
.15	.137	.006	2.175	.050	30.71	.73	466.0	10.7
.21	.136	.005	2.375	.130	33.41	1.88	502.8	27.4
.28	.136	.004	2.593	.303	36.28	4.35	540.6	62.7
.36	.137	.002	2.735	.636	37.96	9.02	560.1	128.5
.45	.139	.001	2.611	1.152	35.82	16.12	524.7	226.7
.55	.142	.000	2.077	1.700	28.03	23.43	411.4	324.4
.67	.144	.000	1.260	2.022	16.60	27.36	251.4	371.8
.82	.146	.001	.544	1.908	6.93	26.26	121.0	348.5
1.01	.147	.003	.141	1.739	1.79	22.27	56.0	286.7
1.25	.147	.006	-.016	1.449	.10	17.83	39.4	220.4
1.55	.145	.008	-.043	1.189	.18	13.89	46.8	162.9
1.95	.143	.010	-.010	.956	1.10	10.39	65.2	113.3
2.45	.140	.010	.051	.759	2.34	7.52	86.9	74.8
3.05	.139	.008	.119	.599	3.61	5.31	107.3	47.1
3.80	.139	.005	.190	.465	4.83	3.59	125.6	27.7
4.70	.139	.002	.254	.360	5.87	2.39	140.2	15.8
5.80	.140	.001	.311	.279	6.74	1.58	151.5	9.0
7.10	.141	.000	.359	.219	7.40	1.08	159.7	5.3
8.70	.141	.000	.398	.174	7.92	.76	166.0	3.3
10.70	.142	.000	.431	.138	8.33	.55	170.9	2.2

FREQUENCY PARAMETER	$\frac{\omega^2 d}{2g}$	DIMENSIONS
A'_{33}	heave added mass	t-sec2/m2
N'_{z}	heave damping	t-sec/m2
M_{s}	sway added mass	t-sec2/m2
N_{s}	sway damping	t-sec/m2
$M_{s.r}$	added mass for sway-roll cross coupling	t-sec2/m2
$N_{s.r}$	damping for sway-roll cross coupling	t-sec/m2
I_{r}	added moment of inertia in roll	t-sec2
N_{r}	roll damping	r-sec

III.4 Response Amplitude Operators

A detailed description of the theory of response amplitude operators can be found in the user manual for SCOMOT, the second part of the U.S.C.G. ship motion program. Briefly, the response amplitude operator is a ship's response to regular sinusoidal waves. The ship is consi ered to be advancing at a constant forward speed with arbitrary heading in regular sinusoidal waves, and it is assumed that the six degree of freedom motions are linear and harmonic. Under the assumptions that the responses are linear and harmonic and lateral with symmetry with the center of gravity on the centerline, the six linear coupled equations of motion reduce two sets of three coupled equations written in terms of exciting forces, hydrodynamic coefficients, etc.

As previously stated, more detailed study of the theory can be obtained from the SCOMOT manual. The primary considera-tion at this point is that now all data (offsets, weight distribu-tion, hydrodynamic properties, etc.) has been obtained to complete the vessel portion of the motions problem as expressed in the flow diagram.

III.4.1 Responses Prepared For Specific Ships

RAOs for each ship were determined at the design draft, and were prepared for midship vertical bending, shear force, and vertical and lateral acceleration. RAOs are expressed by amplitude and phase angle for varying wave frequency and wave angle.

For the SL-7, design values have been prepared for vertical bending moment Φ, vertical shear force Φ, vertical acceleration at the FP, .2L aft of the FP, amidships and lateral acceleration at the top of the containers. Additional long-term reponses for a one-year period were tabulated for the most severe Atlantic (G128S9) spectra and most severe Pacific spectra (G045S2). For each of these spectra, responses were calculated with varying speed (0 to 30 knots) and heading (0 to 180 degrees, in increments of 30 degrees).

Responses for the VLCC included vertical acceleration at the bow, and lateral acceleration at the bridge. For each of these responses for the 15 FNOC grid points considered are the detailed short-term responses, the long-term results for individ-ual wave height groups, and the combined long-term results based on an equal probability of occurrence of wave height groups. The same responses were prepared for the two remaining vessels.

IV. SHIPPING OF WATER PREDICTIONS

Shipping of water (occurrence of deck wetness) is an important consideration in ship operation. Excessive deck wetness can result in damage to the ship and/or cargo, loss of cargo, poor working conditions on deck, etc. International Load Line Convention Regulations exist in order to ensure that ships operate with adequate freeboard. To assess the Load Line Regulations, a study of shipping of water occurrences has been undertaken as part of this report, based on the theory of Ochi [10].

IV.1 Method of Analysis

Like other responses, the probability of shipping of water is a result of the interaction of ship characteristics and wave data. The results are tabulated in terms of occurrences per hour by wave height group at an equal probability of wave angle. Occurrences are also listed for wave angles from 0 to 180 in increments of 15 degrees. Of course, following seas (0 degrees) result in the least shipping of water occurrences and head seas yield the worst conditions.

For the SL-7, slamming and shipping of water probabilities were calculated at the deck edge at the FP, 0.2L aft of the FP, and amidships for the actual freeboard, the minimum freeboard required by load line convention, as well as 1.4, 1.8, 2.2 and 2.6 x the minimum required freeboard. This was done using the G045S2 and G128S9 spectral families (one Atlantic and one Pacific).

The second vessel considered was the VLCC. As with the SL-7 containership, the slamming and shipping of water probabilities were explored for G045S2 and G128S9 spectral families at the deck edge at points at the FP, 0.2L aft of the FP, and amidships for actual freeboard, minimum required freeboard, and 1.4, 1.8, 2.2 and 2.6 x minimum required freeboard.

Responses alone for the 87,000 DWT tanker and the general cargo ship are identical to those for the VLCC except that slamming and shipping of water points included are for freeboards corresponding to the actual, the minimum required, and 0.6, 0.8, 1.2, and 1.4 x the minimum required freeboard.

IV.2 Minimum Freeboard Requirements

Minimum freeboard requirements have been established by the load line convention and consist of a base tabular freeboard which is a function of length and type of ship (liquid carrying or dry cargo). Corrections are then made based on block coefficient, depth, superstructure (deduction), and sheer. Minimum required freeboards for the four vessels in this study are calculated as follows:

LOAD LINE CONVENTION

TABLE FREEBOARD	From Table
CORRECTION FOR BLOCK COEFFICIENT	$\frac{C_b + 0.68}{1.36}$
DEPTH CORRECTION	$(D - \frac{L}{15})\ R$
SUPERSTRUCTURE DEDUCTION	See Load Line Convention
SHEER CORRECTION	See Load Line Convention
ASSIGNED FREEBOARD	Total

MINIMUM REQUIRED FREEBOARD

VESSEL TYPE	SL-7 B	VLCC A	TANKER A	GEN. CARGO B
Table Freeboard (in)	167.5	122.5	113.84	91.34
x CB Correction =	167.5	134.75	124.09	91.34
+ Depth Correction (inches)	15.9	24.45	11.06	32.19
- Superstructure Deduct (inches)	0	0	0	16.48
+ Sheer Correction (inches)	0	0	24.86	6.85
Assigned Freeboard (inches)	183.4	159.2	160.01	141.0
(feet)	15.28	13.27	13.34	11.75

IV.3 Summary of Results

Shipping of water results are found on Tables IV.1 - IV.8 and Figures IV.1 - IV.2.

Deck wetness occurs first for the general cargo ship, the smallest of the four vessels involved in the study. By operating at a freeboard close to the minimum, shipping of water occurs at small wave heights (as small of 6.5 feet). This tends to justify the addition of a large forecastle on a small ship.

Although the four ships operate at different freeboards and shipping of water occurs at varied wave heights, it should be noted that the addition of a forecastle to the general cargo ship and the 87,000 DWT tanker puts them in the same operating range as the SL-7 and the VLCC. This is illustrated by the graph of shipping of water at the bow (Figure IV.1). This addition of a forecastle on the general cargo ship has the same effect as increasing the freeboard, but it does not result in a decrease in cargo capacity.

The VLCC and the smaller 87,000 DWT tanker exhibit similar characteristics with regard to shipping of water. This is expected because they are both liquid carrying (Type A) vessels. Curves of wave height versus freeboard at which shipping of water occurs have similar shape and magnitude for both these ships and, therefore, comparison of shipping of water tables for these two ships can be revealing. They are quite similar with regard to deck wetness at the bow because they have been designed to operate in the same range. The VLCC is designed to operate at a freeboard equal to nearly twice the minimum required by the Load Line Convention. However, the smaller tanker is loaded to almost the minimum required freeboard and is brought up to operational level equal to the VLCC through the use of a forecastle. Hence, the occurrence of deck wetness at the bow is almost identical for both ships at their actual operating freeboards.

Shipping of water characteristics for the SL-7 containership reveal an important design consideration. The operating speed of the SL-7 is nearly twice that of the other ships involved in the study. Figure IV.2 indicates that the actual operating freeboard of the SL-7 is more than twice what it is required to be. This is a reflection of the fact that the ship operates at 30 knots with containers stacked four high on deck.

Further observation of shipping of water statistics shows that for various types of ships the proportion of the minimum freeboard by which the freeboard must be increased in order to avoid deck wetness is approximately the same. In other words, the slopes are approximately the same. Typically, a doubling of freeboard results in an increase of only about 5 feet in the operating wave height. Again, this is illustrated by Figures IV.1 and IV.2.

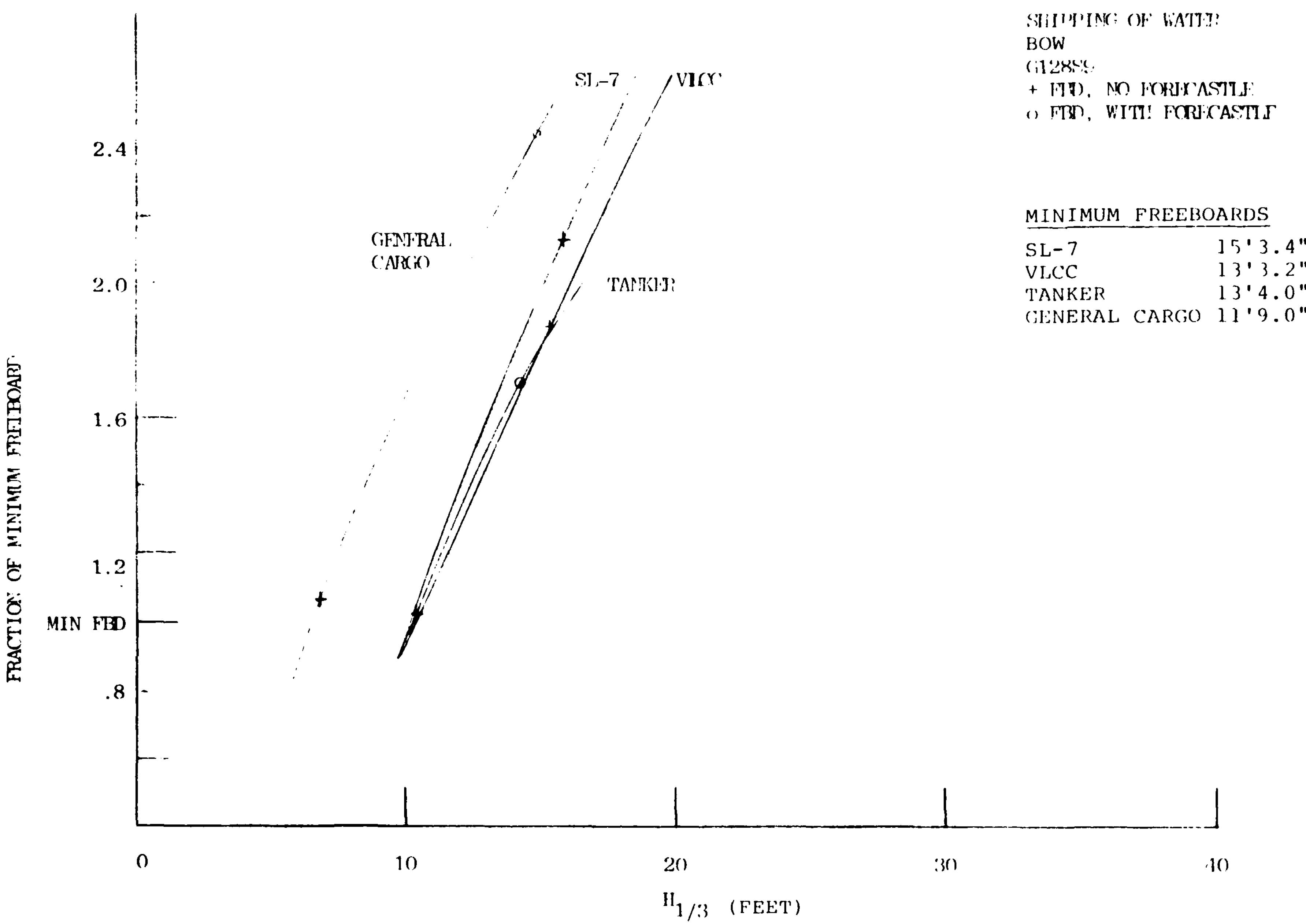

Figure IV.1: SHIPPING OF WATER, BOW

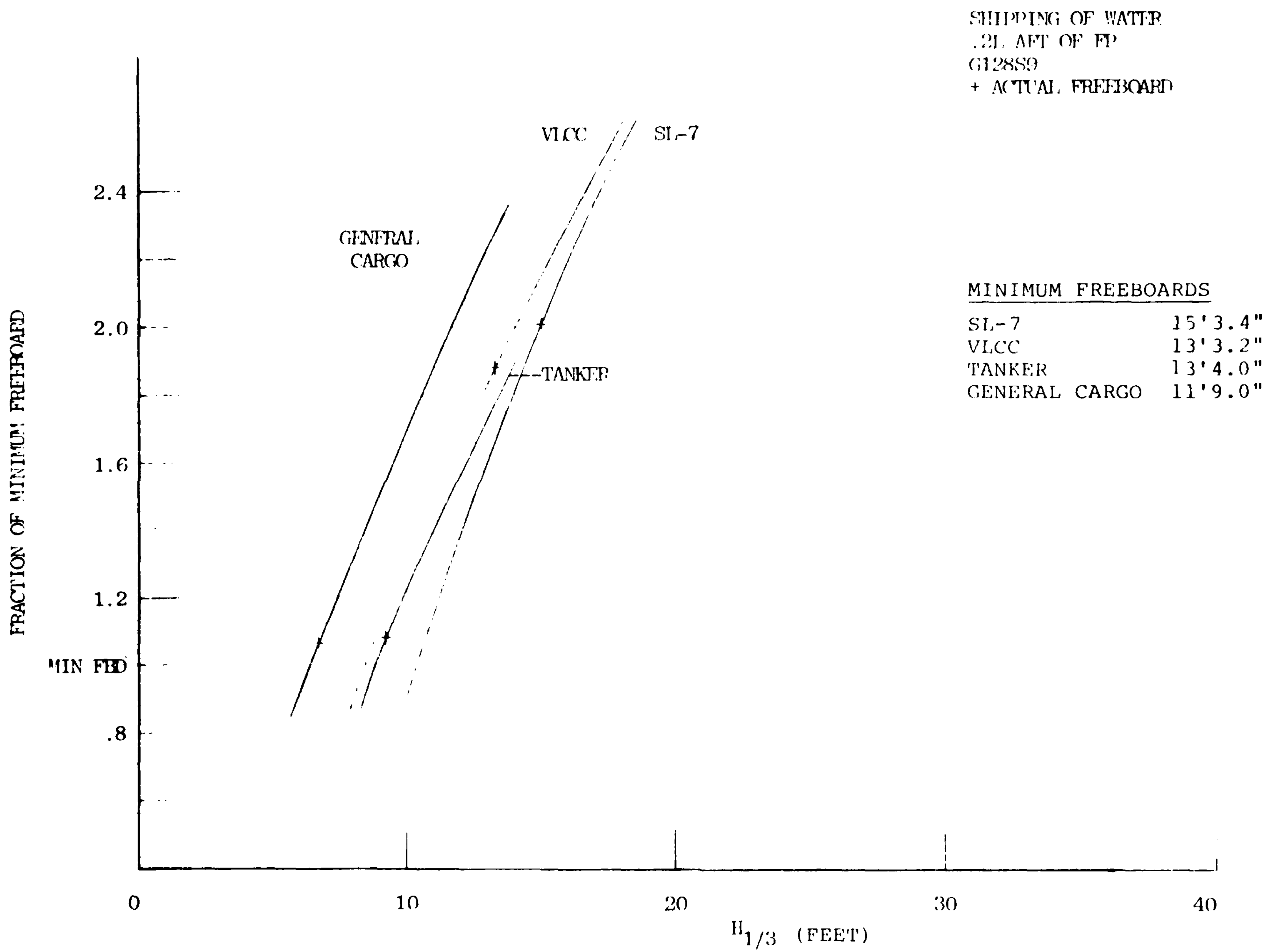

Figure IV.2: SHIPPING OF WATER, .2L AFT OF FP

TABLE IV.1

SL-7 CONTAINERSHIP, FULL LOAD
SHIPPING OF WATER STATISTICS, OCCURRENCES/HOUR
G045S2 SPECTRA

		-SIGNIFICANT WAVE HEIGHT-								
	FREEBOARD (FEET)	0-3	3-6	6-9	9-12	12-16	16-21	21-27	27-32	32-40
BOW										
MIN FBD	15.28	0	0	0	.41	13.31	76.75	166.32	221.88	253.37
1.4x MIN FBD	21.39	0	0	0	0	.51	16.34	75.61	138.66	186.55
1.8xMIN FBD	27.50	0	0	0	0	.01	2.17	27.00	74.98	124.93
ACTUAL FBD	32.55	0	0	0	0	0	.29	9.68	40.61	83.76
2.2xMIN FBD	33.61	0	0	0	0	0	.18	7.59	35.14	76.23
2.6xMIN FBD	39.73	0	0	0	0	0	.01	1.61	13.95	41.80
.2L AFT OF FP										
MIN FBD	15.80	0	0	0	.20	8.20	56.43	136.30	189.63	221.69
1.4xMIN FBD	22.12	0	0	0	0	.29	11.06	58.66	113.63	157.95
1.8xMIN FBD	28.44	0	0	0	0	0	1.45	20.53	60.07	103.60
ACTUAL FBD	31.84	0	0	0	0	0	.33	9.65	37.99	76.49
2.2xMIN FBD	34.76	0	0	0	0	0	.12	5.69	27.64	62.12
2.6xMIN FBD	41.08	0	0	0	0	0	.01	1.14	10.52	32.98
AMIDSHIPS										
MIN FBD	15.82	0	0	0	.28	8.68	49.03	113.10	153.93	180.62
1.4xMIN FBD	22.14	0	0	0	0	.29	8.63	45.21	86.54	122.64
1.8xMIN FBD	28.47	0	0	0	0	0	.83	13.10	39.74	72.69
ACTUAL FBD	31.55	0	0	0	0	0	.18	5.85	23.96	51.72
2.2xMIN FBD	34.80	0	0	0	0	0	.05	2.96	15.63	38.82
2.6xMIN FBD	41.13	0	0	0	0	0	0	.49	5.02	18.09

TABLE IV.2

SL-7 CONTAINERSHIP, FULL LOAD
SHIPPING OF WATER STATISTICS, OCCURRENCES/HOUR
G128S9 SPECTRA

	FREEBOARD (FEET)	-SIGNIFICANT WAVE HEIGHT- 0-3	3-6	6-9	9-12	12-16	16-21	21-27	27-32	32-40
BOW										
MIN FBD	15.28	0	0	0	.41	16.23	79.99	173.27	210.46	243.99
1.4x MIN FBD	21.39	0	0	0	0	.75	17.63	82.89	126.72	176.43
1.8xMIN FBD	27.50	0	0	0	0	.01	2.45	31.63	65.26	115.39
ACTUAL FBD	32.55	0	0	0	0	0	.34	12.11	33.67	74.44
2.2xMIN FBD	33.61	0	0	0	0	0	.22	9.65	28.80	68.38
2.6xMIN FBD	39.73	0	0	0	0	0	.01	2.26	10.62	36.17
.2L AFT OF FP										
MIN FBD	15.80	0	0	0	.26	10.07	59.25	142.64	178.78	213.06
1.4x MIN FBD	22.12	0	0	0	0	.43	12.09	64.59	102.85	148.85
1.8xMIN FBD	28.44	0	0	0	0	.01	1.66	24.07	51.62	51.62
ACTUAL FBD	31.87	0	0	0	0	0	.40	11.84	31.43	68.99
2.2xMIN FBD	34.76	0	0	0	0	0	.15	7.21	22.28	55.31
2.6xMIN FBD	41.08	0	0	0	0	0	.01	1.60	7.82	28.24
AMIDSHIPS										
MIN FBD	15.82	0	0	0	.35	9.73	51.09	117.24	145.48	174.22
1.4x MIN FBD	22.14	0	0	0	0	0	9.33	49.06	78.04	115.79
1.8xMIN FBD	28.47	0	0	0	0	0	.94	15.12	33.65	66.68
ACTUAL FBD	31.55	0	0	0	0	0	.21	7.03	19.47	46.57
2.2xMIN FBD	34.80	0	0	0	0	0	.06	3.69	12.27	34.40
2.6xMIN FBD	41.13	0	0	0	0	0	0	.66	3.59	15.37

TABLE IV.3

VLCC
SHIPPING OF WATER STATISTICS, OCCURRENCES/HOUR
G045S2 SPECTRA

		-SIGNIFICANT WAVE HEIGHT-								
	FREEBOARD (FEET)	0-3	3-6	6-9	9-12	12-16	16-21	21-27	27-32	32-40
BOW										
MIN FBD	11.82	0	0	0	.48	11.15	64.40	141.02	190.28	218.14
1.4xMIN FBD	16.55	0	0	0	0	.37	12.38	60.15	116.01	159.82
1.8xMIN FBD	21.28	0	0	0	0	.05	4.47	35.53	85.43	131.84
ACTUAL FBD	22.22	0	0	0	0	0	.85	15.09	51.95	96.42
2.0xMIN FBD	23.65	0	0	0	0	0	.38	9.96	40.81	82.86
2.2xMIN FBD	26.01	0	0	0	0	0	.09	4.72	26.47	63.10
.2L AFT OF FP										
MIN FBD	11.80	0	0	0	1.94	24.45	89.92	163.95	202.87	224.57
1.4xMIN FBD	16.53	0	0	0	.01	1.73	24.15	82.82	134.19	171.59
1.8xMIN FBD	21.25	0	0	0	0	.33	10.62	54.05	103.64	145.03
ACTUAL FBD	22.14	0	0	0	0	.02	2.89	27.47	68.80	111.08
2.0xMIN FBD	23.61	0	0	0	0	.01	1.48	19.40	55.75	96.87
2.2xMIN FBD	25.97	0	0	0	0	0	.47	10.67	38.83	75.55
AMIDSHIPS										
MIN FBD	11.82	0	0	0	1.14	19.00	76.69	149.61	189.22	213.19
1.4xMIN FBD	16.55	0	0	0	0	1.05	17.58	68.99	116.52	154.09
1.8xMIN FBD	21.28	0	0	0	0	.17	7.00	42.53	86.06	125.79
ACTUAL FBD	22.06	0	0	0	0	.01	1.71	20.25	54.07	92.15
2.0xMIN FBD	23.65	0	0	0	0	0	.77	13.32	41.59	77.29
2.2xMIN FBD	26.01	0	0	0	0	0	.21	6.77	27.21	58.18

TABLE IV.4

VLCC
SHIPPING OF WATER STATISTICS, OCCURRENCES/HOUR
G128S9 SPECTRA

	FREEBOARD (FEET)	-SIGNIFICANT WAVE HEIGHT- 0-3	3-6	6-9	9-12	12-16	16-21	21-27	27-32
BOW									
MIN FBD	11.82	0	0	0	.56	13.65	66.94	147.58	182.38
1.4xMIN FBD	16.55	0	0	0	0	.55	13.30	66.95	108.20
1.8xMIN FBD	21.28	0	0	0	0	.08	4.90	41.08	78.35
ACTUAL FBD	22.22	0	0	0	0	0	.97	18.56	46.35
2.0xMIN FBD	23.65	0	0	0	0	0	.44	12.93	35.93
2.2xMIN FBD	26.01	0	0	0	0	0	.11	6.32	22.75
.2L AFT OF FP									
MIN FBD	11.80	0	0	0	2.26	27.54	92.86	168.36	195.02
1.4xMIN FBD	16.53	0	0	0	.01	2.19	25.69	88.60	125.16
1.8xMIN FBD	21.25	0	0	0	0	.45	11.51	59.32	94.86
ACTUAL FBD	22.14	0	0	0	0	.04	3.22	31.39	61.12
2.0xMIN FBD	23.61	0	0	0	0	.01	1.67	22.65	48.77
2.2xMIN FBD	25.97	0	0	0	0	0	.54	12.91	33.09
AMIDSHIPS									
MIN FBD	11.82	0	0	0	1.34	20.78	79.30	153.50	180.61
1.4xMIN FBD	16.55	0	0	0	.01	1.25	18.75	73.60	106.93
1.8xMIN FBD	21.28	0	0	0	0	.22	7.61	46.49	77.06
ACTUAL FBD	22.06	0	0	0	0	.01	1.91	22.98	46.63
2.0xMIN FBD	23.65	0	0	0	0	0	.87	15.44	35.11
2.2xMIN FBD	26.01	0	0	0	0	0	.25	8.12	22.19

TABLE IV.5

87,000 DWT TANKER
SHIPPING OF WATER STATISTICS,
OCCURRENCES/HOUR
G045S2 SPECTRA

	FREEBOARD (FEET)	-SIGNIFICANT WAVE HEIGHT- 0-3	3-6	6-9	9-12	12-16	16-21	21-27
BOW								
.6xMIN FBD	8.02	0	0	.85	20.50	82.02	170.90	234.85
.8xMIN FBD	10.70	0	0	.01	1.93	23.85	94.02	172.75
MIN FBD	13.37	0	0	0	.10	4.97	44.01	116.92
1.2xMIN FBD	16.05	0	0	0	0	.75	17.68	73.14
1.4xMIN FBD	18.72	0	0	0	0	.08	6.11	42.34
ACTUAL FBD*	23.34	0	0	0	0	0	.71	13.96
.2L AFT OF FP								
.6XMIN FBD	8.02	0	0	3.17	13.20	121.98	200.82	251.46
.8xMIN FBD	10.70	0	0	.07	7.40	49.61	127.87	198.59
MIN FBD	13.37	0	0	0	.76	15.60	71.57	146.62
ACTUAL FBD	14.40	0	0	0	.28	9.35	55.35	128.18
1.2xMIN FBD	16.05	0	0	0	.05	3.80	35.22	101.19
1.4xMIN FBD	18.72	0	0	0	0	.71	15.23	65.29
AMIDSHIPS								
.6xMIN FBD	8.02	0	0	1.69	34.54	109.13	186.87	240.96
.8xMIN FBD	10.70	0	0	.02	4.93	40.52	111.81	183.12
MIN FBD	13.38	0	0	0	.40	11.34	57.76	128.67
ACTUAL FBD	14.38	0	0	0	.14	6.54	43.43	110.48
1.2xMIN FBD	16.05	0	0	0	.02	2.39	25.77	88.59
1.4xMIN FBD	18.72	0	0	0	0	.38	9.93	50.21

*Note presence of forecastle

TABLE IV.6

87,000 DWT TANKER
SHIPPING OF WATER, OCCURRENCES/HOUR

G128S9 SPECTRA

-SIGNIFICANT WAVE HEIGHT-

	FREEBOARD (FEET)	0-3	3-6	6-9	9-12	12-16	16-21	21-27
BOW								
.6xMIN FBD	8.025	0	0	.63	22.10	89.67	174.38	236.82
.8xMIN FBD	10.70	0	0	0	2.18	28.00	97.22	178.04
MIN FBD	13.37	0	0	0	.12	6.38	46.27	123.87
1.2xMIN FBD	16.05	0	0	0	0	0	1.08	18.96
1.4xMIN FBD	18.72	0	0	0	0	0	.14	6.71
ACTUAL FBD*	23.34	0	0	0	0	0	.81	17.14
.2L AFT OF FP								
.6XMIN FBD	8.02	0	0	3.30	46.56	127.42	203.71	251.88
.8xMIN FBD	10.70	0	0	.07	8.39	53.65	131.01	201.52
MIN FBD	13.37	0	0	0	.93	17.65	74.28	151.28
ACTUAL FBD	14.40	0	0	0	.35	10.78	57.77	133.24
1.2xMIN FBD	16.05	0	0	0	.06	4.53	37.13	106.56
1.4xMIN FBD	18.72	0	0	0	0	.91	16.36	70.43
AMIDSHIPS								
.6xMIN FBD	8.02	0	0	2.11	37.52	112.42	189.45	241.44
.8xMIN FBD	10.70	0	0	.03	5.67	42.60	114.40	185.78
MIN FBD	13.38	0	0	0	.50	12.23	59.81	132.64
ACTUAL FBD	14.38	0	0	0	.17	7.14	45.20	114.68
1.2xMIN FBD	16.05	0	0	0	.03	2.66	27.07	87.87
1.4xMIN FBD	18.72	0	0	0	0	.44	10.61	54.01

*Note presence of forecastle

TABLE IV.7

GENERAL CARGO SHIP
SHIPPING OF WATER, OCCURRENCES/HOUR

G045S2 SPECTRA

	FREEBOARD (FEET)	-SIGNIFICANT WAVE HEIGHT- 0-3	3-6	6-9	9-12	12-16	16-21	21-27
BOW								
.6xMIN FBD	7.03	0	.38	24.67	129.82	232.05	291.26	322.46
.8xMIN FBD	9.38	0	0	2.57	50.08	144.46	225.84	280.45
MIN FBD	11.72	0	0	.15	15.05	79.36	168.70	235.02
1.2xMIN FBD	14.06	0	0	0	3.56	38.67	111.21	190.05
1.4xMIN FBD	16.41	0	0	0	.68	16.86	71.13	148.63
ACTUAL FBD*	28.42	0	0	0	0	.05	3.18	26.76
.2L AFT OF FP								
.6xMIN FBD	7.03	0	.38	24.51	121.68	216.91	275.09	305.92
.8xMIN FBD	9.28	0	0	2.55	45.35	131.08	209.13	262.54
MIN FBD	11.71	0	0	.14	12.98	69.27	147.82	216.37
ACTUAL FBD	12.39	0	0	.06	8.62	56.21	131.95	203.10
1.2xMIN FBD	14.06	0	0	0	2.89	32.21	97.47	171.56
1.4xMIN FBD	16.41	0	0	0	.51	13.26	60.17	131.13
AMIDSHIPS								
.6xMIN FBD	7.03	0	.26	21.14	105.75	191.08	247.76	278.90
.8xMIN FBD	9.40	0	0	1.96	36.36	109.15	182.18	234.38
MIN FBD	11.75	0	0	.09	9.21	53.11	122.67	187.39
ACTUAL FBD	11.84	0	0	.08	8.68	51.51	120.62	185.60
1.2xMIN FBD	14.10	0	0	0	1.72	22.02	75.64	142.54
1.4xMIN FBD	16.45	0	0	0	.24	7.77	42.71	103.15

*Note presence of forecastle

TABLE IV.8

GENERAL CARGO SHIP
SHIPPING OF WATER, OCCURRENCES/HOUR

G128S9 SPECTRA

	FREEBOARD (FEET)	-SIGNIFICANT WAVE HEIGHT- 0-3	3-6	6-9	9-12	12-16	16-21	21-27
BOW								
.6xMIN FBD	7.03	0	.16	31.29	137.79	231.86	292.36	320.06
.8xMIN FBD	9.38	0	0	3.90	55.16	144.53	227.56	279.82
MIN FBD	11.72	0	0	.28	17.38	79.54	165.74	236.03
1.2xMIN FBD	14.06	0	0	.01	4.35	38.84	113.26	192.37
1.4xMIN FBD	16.41	0	0	0	.88	16.97	72.93	151.81
ACTUAL FBD*	28.42	0	0	0	0	.05	3.41	29.08
.2L AFT OF FP								
.6xMIN FBD	7.03	0	.17	29.37	129.93	217.53	276.11	303.73
.8xMIN FBD	9.38	0	0	3.52	50.50	131.68	210.60	262.15
MIN FBD	11.72	0	0	.24	15.25	69.74	149.49	217.62
ACTUAL FBD	12.39	0	0	.10	10.30	56.64	133.62	204.75
1.2xMIN FBD	14.06	0	0	.01	3.62	32.52	99.07	174.04
1.4xMIN FBD	16.41	0	0	0	.68	13.43	61.52	134.36
AMIDSHIPS								
.6xMIN FBD	7.05	0	.11	24.08	114.10	192.83	248.84	277.29
.8xMIN FBD	9.40	0	0	2.48	41.35	110.73	183.52	234.73
MIN FBD	11.75	0	0	.13	11.21	54.24	124.04	189.39
ACTUAL FBD	11.84	0	0	.12	10.60	52.61	121.98	187.66
1.2MIN FBD	14.10	0	0	0	2.27	22.67	76.84	145.69
1.4xMIN FBD	16.45	0	0	0	.34	8.08	43.62	106.85

*Note presence of forecastle

V. EXTREME BENDING MOMENT PREDICTIONS

Extreme predictions are based on an approach which combines wave spectra (hindcast, measured or theoretical) with response amplitude operators (RAOs) into a response spectrum. It is from this response spectrum that long term values are ascertained through statistical extrapolation. By observing the results at a particular point in the procedure or by emphasizing a particular element of the process or by varying a data source while keeping all other elements constant, it is possible to gauge the effect of the various parameters involved. Some of the elements examined in this report are the sensitivity of long term prediction to spectral shape and the effect of different data sources on these prediction.

V.1 Statistical Extrapolation

The short term description of the sea is the basic input required in order to determine the response of a vehicle in a particular sea. The definition of short term is a period of time short enough to make it possible to describe the sea as a stationary random process. The stationary property does not imply that the surface of the sea remains unchanged. On the contrary, at any given instant of time, the surface pattern is unique. However, the statistical properties of the short term sea, defined by its spectrum, may be regarded as constant over such a period of time. The significant wave height and average period alone cannot characterize the short term sea; hence, the actual wave spectrum, describing how the components of the surface pattern are distributed over frequency, is required. When the random process is stationary the spectrum remains essentially unchanged.

The superposition of the wave spectrum on the transfer function yields a response spectrum usually characterized by its root-mean-square (rms) value. When several spectra, each representing the same basic environmental conditions defined by subsets for the range of wave heights between 0-50 feet are superimposed, the trend of the particular response as a function of the wave height is obtained. The distribution of the rms and its standard deviation as a function of the wave state is a useful intermediate step in the analysis of ship motion.

Short term responses, as described above, are limited to the mean rms value or the mean +/- standard deviation. Hence, it does not yield extreme values nor does it indicate the level of response expected over a longer period of operation.

While the mean rms value is self-explanatory the reason for the scatter is the variations in spectral shape as well as the averaging of the responses over different headings. The short term results also include the number of reversals expected per hour which is a necessary input of relating long term return periods expressed in terms of reversals to a specific period such as 24 hours, one week or lifetime of the vessel. The need to extend the results from the short term response representing the response over a period of up to three hours (since steady state of the sea condition is assumed) to more realistic operational periods under non-steady state sea conditions, i.e. long term response is often ignored in many analyses and the extreme value used is a multiple of the rms response. This approach can lead to substantial errors and should be avoided. While the short term rms value can be easily expressed in terms of the significant capabilities (rms x 2) the highest expected values must be related to a longer return period and not the short term steady state interval. Since tables of exceedance and persistance relate to extreme values and are compiled from data covering several years, a consistent approach should be applied in the case of the responses.

In order to extrapolate the above data to a long term distribution, the following probability model is used based on these assumptions:

1. The response values, X (peak-to-trough or trough-to-peak), due to any one spectra within a wave height group are Rayleigh distributed.

2. In each wave height group the root-mean-square (rms) values of the responses, from many spectra, are normally distributed.

The combined probability distribution is then the product of the equations representing the Rayleigh distribution of X for each group of spectra and the normal probability distribution of rms:

$$p(x) = p(x) \cdot f(rms)$$

V.2 Sensitivity to Spectral Shape

The tabulated values of long term responses illustrate the effect of varying spectral shape in long term analysis. These long term values have been calculated for each ship and have assumed an equal probability of occurrence of wave height groups in order to exaggerate the effect of spectral shape variation. The last group of tables which illustrate primarily the effect of different data sources and give realistic results (they include realistic exceedance data) can also be used to gauge sensitivity of long term results to spectral shape if the results are considered for the same exceedance levels. Results of this analysis are tabulated in Attachment B.

Tables B.2 to B.7 contain results of various responses for the SL-7 obtained by varying spectral shape using hindcast data. The same set of responses have been tabulated for the VLCC in Tables B.16 to B.21, the 87,000 DWT Tanker in Tables B.22 to B.27, and the general cargo ship in Tables B.28 to B.33. Referring back to Table II.2 (periods of wave height groups for hindcast spectra), it is possible to gauge the effect of spectral shape on results.

V.3 *Effect of Different Data Sources*

The last group of tables in this section illustrate the effect of different data sources on long term prediction. Results have been tabulated using these spectral sources (hindcast for SOWM grid point 128, Station INDIA measured, and ISSC two parameter spectra for grid point 128) and three sources of exceedance data: hindcast (grid point 128), measured and observed (Hogben and Lumb). In addition, results were tabulated using these same three spectra and three different hindcast exceedances (one for each route mentioned in Section II.1). This array of results can then be compared to classification society rules.

Table B.34 lists ISSC wave heights and periods for grid point 128. The results of varying spectra and percent occurrences of wave height groups are included in Tables B.35 to B.39. The spectrum which yields the most severe results is Station India measured spectra followed by the hindcast and mathematical spectra for nearby grid point 128. The most severe exceedance data is hindcast followed by measured and then observed.

V.4 Effect of Seamanship

The preceding comparisons and analyses assumed equal probability of heading. This means that each heading receives equal weight and the resulting response is an average of what the response would be for each heading considered individually. Of course, in reality an operator can take evasive action in order to avoid excessive responses expected under certain conditions. Such action can include changing course as well as speed. The effect of such changes can be seen for the SL-7 containership in Tables B.8 to B.15. These results show that a change in speed has little effect on responses, but a change in heading can significantly affect responses. Specifically, vertical bending moment amidships is much greater in head seas than it is in following seas or beam seas.

V.5 Classification Society Rules

Classification society rules regarding wave induced shear force and bending moment are as follows:

<u>American Bureau of Shipping</u>

$$Fw = 1.6\ Mw/L$$

$$Mw = C_2\ L^2\ B\ He\ K_b$$

where K_b and C_2 are functions of C_b.

<u>Lloyd's Register of Shipping</u>

$$Fw = e^{-.0035L}\ BL^2\ (C_b + 0.7)\ \text{tonne}$$

$$Mw = Ow\ C_1\ L^2\ B\ (C_b + 0.7)\ \text{tonnef.m}$$

where Cl is a function of L and)w is a stress dependent on ship type and service.

<u>Det Norske Veritas</u>

$$Mw = K_1\ C_1\ L^2\ B\ (C_b + .7)$$

where Cl is a function of length.

The maximum allowable wave induced bending moments were calculated for the four vessels by classification society rules. The results are included in Table V.1, and reproduced in Table B.1., along with the results of calculations performed using various spectra and exceedance data.

In all cases but one the general cargo vessel the wave induced bending moments allowed by the rules are exceeded. For example, calculations using hindcast data for the VLCC result in a wave induced bending moments 72% in excess of the American Bureau of Shipping classification rules. Results for the general cargo ship using hindcast data are approximately 12% lower than that calculated from the rules.

It should be emphasized that the formulation of this bending moment is only one step in determining the required section modulus and must be considered in light of allowable bending stress. Required section modulus is a function of both bending moment and bending stress. American Bureau of Shipping rules specify allowable bending stress as a function of ship length which ranges from 22,000 psi to 24,300 psi. The difference between the calculated wave induced bending moment and that specified by the rules as a maximum can be accounted for by a difference in bending stress. In either case, the bending stress is below the yield stress and what results is a required section modulus with an adequate factor of safety.

TABLE V.1

WAVE INDUCED BENDING MOMENT

	SL-7	VLCC	TANKER	GENERAL CARGO
LENGTH(ft)	880.5	879.6	763.0	492.30
BEAM(ft)	105.0	127.74	125.0	75.26
DEPTH(ft)	64.0	66.79	54.5	43.49
Cb	.549	.816	.799	.568
SPEED(knots)	30.0	16.0	16.5	16.0
WAVE-INDUCED BENDING MOMENT Ø (L.TONS.FT)				
ABS	1,095,026	1,528,516	1,058,063	191,381
LLOYD'S	982,671	1,446,681	1,017,541	188,166
DNV	982,666	1,447,870	1,014,457	188,311
HINDCAST EXCEEDANCE:				
Hindcast Spectra	1,403,000	2,632,100	1,621,400	167,600
Station INDIA	1,574,000	2,807,100	1,778,000	190,310
ISSC Spectra	1,402,000	2,603,000	1,614,000	167,600
MEASURED EXCEEDANCE:				
Hindcast Spectra	1,263,100	2,375,000	1,448,000	157,400
Station INDIA	1,444,000	2,578,000	1,633,300	176,700
ISSC Spectra	1,246,400	2,274,000	1,423,200	154,300
OBSERVED EXCEEDANCE:				
Hindcast Spectra	1,094,200	1,965,200	1,239,000	150,440
Station INDIA	1,238,000	2,187,100	1,394,100	162,920
ISSC Spectra	1,081,400	1,936,000	1,224,400	143,720

VI. ESTIMATES OF VERTICAL ACCELERATION

Criteria used to estimate vertical accelerations established by the Coast Guard consists of:

MOTION	AMPLITUDE	PERIOD(sec.)
ROLL	30 deg each side	10
PITCH	6 deg (1/2 amp)	7
HEAVE	L/80 (1/2 amp)	8

The pitch and roll periods of the vessels considered in this study are tabulated in Table III.1. Note, however, that the maximum acceleration loadings are more closely related to the period of the wave induced vessel response (or more properly, to the response spectrum), and not to the natural or resonant periods, per se. Thus, the pitch component of the vertical acceleration will usually occur at a frequency nearer the wave encounter frequency, while the roll component may occur predominantly at either the resonant roll period, or the period of the wave spectral peak, depending on the relationship between the two. Thus, it is more meaningful to evaluate the vertical acceleration formula on the basis of the actual acceleration predictions, rather than comparing the assumed periods and amplitudes for each component of the vertical acceleration.

The vertical accelerations which result from these motions were calculated at three points for the SL-7 Containership (bow, .2L aft of FP, amidships) and at the bow for the three remaining vessels. The accelerations calculated at the bow were then compared to the vertical accelerations which occur at the same point as a result of long term analysis using all combinations of hindcast, measured and ISSC two-parameter spectra with hindcast, measured and observed exceedance. The hindcast and ISSC spectra used were associated with grid point 128 and the measured data was from Station INDIA (see Table VI.1).

Results of this study indicate that the criteria used to estimate vertical acceleration tend to be conservative for the two tankers and under estimate accelerations for the SL-7 and the general cargo ship. This is most likely a result of the only parameter taken into account being the ship's length (used for calculating heave amplitude). In reality, the greater displacement of the tankers results in smaller heave and pitch amplitudes than for the finer cargo ships. Therefore, it is recommended that the criteria for estimating vertical acceleration be revised slightly in order to reflect the difference between full and fine ships. This can be accomplished by estimating smaller amplitudes of heave and pitch for tanker and larger amplitudes for cargo ships and container ships.

TABLE VI.1

COMBINED LONG TERM VERTICAL ACCELERATION (20 YEARS) AT BOW (FT/S2)

	SL-7 ACTUAL	VLCC ACTUAL	TANKER ACTUAL	GEN CARGO ACTUAL
FORMULA:	49.39	44.62	39.07	31.65
HINDCAST EXCEEDANCE:				
Hindcast Spectra	71.65	25.51	28.57	57.77
Station INDIA	84.42	28.35	32.36	64.65
ISSC Spectra	71.72	25.39	28.54	57.91
MEASURED EXCEEDANCE:				
Hindcast Spectra	64.86	22.80	25.66	54.08
Station INDIA	77.40	26.05	29.62	60.12
ISSC Spectra	63.94	22.37	25.28	53.16
OBSERVED EXCEEDANCE:				
Hindcast Spectra	56.39	19.47	22.07	51.41
Station INDIA	66.47	22.25	25.39	56.24
ISSC Spectra	55.58	19.22	21.82	49.14

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ATTACHMENT A

Hydrostatic Properties and Still Water Bending Moments

INDEX OF ATTACHMENT A

TABLE A.1

WEIGHT BLOCK DATA — SL-7 CONTAINERSHIP

WEIGHT TYPE	BLOCK WEIGHT (L.TONS)	BLOCK LCG (FEET)	FWD END BLOCK (FEET)	AFT END BLOCK (FEET)
1	765.20	19.00	-20.00	42.00
1	1847.70	84.32	42.00	115.25
1	1205.70	143.18	115.25	167.75
1	1613.40	185.52	167.75	207.75
1	1943.60	225.50	207.75	247.75
1	2379.20	265.54	247.75	287.75
1	2305.60	305.53	287.75	327.75
1	2610.80	345.53	327.75	367.75
1	3148.70	385.52	367.75	407.75
1	3343.70	425.51	407.75	447.75
1	3299.00	467.99	447.75	492.75
1	3179.20	512.99	492.75	537.75
1	3293.30	550.00	537.75	562.75
1	3039.80	587.50	562.75	612.75
1	2661.30	635.00	612.75	652.75
1	2898.70	674.35	652.75	697.75
1	2116.10	716.10	697.75	737.75
1	1678.30	756.40	737.75	777.75
1	1597.20	795.55	777.75	817.75
1	1244.50	835.50	817.75	852.50
1	897.70	869.50	852.50	880.50
1	691.30	900.50	880.50	920.50

BLOCK TYPE	SUMMARY WEIGHT (L.TONS)	SUMMARY LCG (FEET)
1	47759.96	478.86
TOTAL	47759.94	478.86

LONGITUDINAL GYRADIUS = 213.10 FEET

TABLE A.2

WEIGHT BLOCK DATA

V . L . C . C .

WEIGHT TYPE	BLOCK WEIGHT (L.TONS)	BLOCK LCG (FEET)	FWD END BLOCK (FEET)	AFT END BLOCK (FEET)
1	1660.80	45.16	.00	78.83
1	1778.60	125.72	78.83	173.30
1	2338.00	225.34	173.30	280.71
1	2005.60	324.95	280.71	371.39
1	1353.15	401.58	371.39	433.48
1	165.90	435.97	433.48	441.68
1	511.60	451.31	441.68	463.70
1	677.80	478.20	463.70	493.92
1	2677.00	554.83	493.92	617.02
1	758.60	631.46	617.02	647.87
1	429.10	654.45	647.87	662.90
1	431.10	669.77	662.90	678.55
1	379.30	685.10	678.55	693.68
1	349.62	700.42	693.68	708.77
1	478.90	714.24	708.77	721.21
1	5802.25	794.26	721.21	882.60
1	11825.01	225.36	173.30	280.71
1	10269.00	325.42	280.71	371.39
1	6974.05	462.88	433.48	493.92
1	11440.98	554.79	493.92	617.02
1	6352.09	127.99	81.35	173.30
1	5868.31	225.34	173.30	280.71
1	10620.69	324.96	280.71	371.39
1	9248.64	432.23	371.39	493.92
1	8029.04	554.83	493.92	617.02
1	6301.27	669.13	617.02	721.28
1	3963.70	401.58	371.39	433.48
1	914.70	737.92	730.37	756.82
1	50.82	750.22	745.50	756.82
1	101.63	743.92	737.95	756.82
1	50.82	819.17	807.03	835.64
1	101.63	806.14	801.65	812.97
1	81.31	787.60	781.66	790.88
1	20.33	750.19	745.59	754.78
1	203.27	849.39	846.97	855.07
1	152.45	748.22	737.95	759.54

BLOCK TYPE	SUMMARY WEIGHT (L.TONS)	SUMMARY LCG (FEET)
1	114366.70	413.97
TOTAL	114366.10	413.97

LONGITUDINAL GYRADIUS = 185.21 FEET

TABLE A.3

WEIGHT BLOCK DATA — 87,000 DWT TANKER

WEIGHT TYPE	BLOCK WEIGHT (L.TONS)	BLOCK LCG (FEET)	FWD END BLOCK (FEET)	AFT END BLOCK (FEET)
1	1120.00	34.00	-21.33	73.50
1	1674.00	126.00	73.50	181.50
1	918.00	208.00	181.50	235.50
1	974.00	262.50	235.50	289.50
1	2035.00	343.50	289.50	397.50
1	518.00	411.00	397.50	424.50
1	518.00	438.00	424.50	451.50
1	1026.00	478.50	451.50	505.50
1	1944.00	559.50	505.50	613.50
1	3543.60	702.90	613.50	788.50
1	8838.00	131.79	73.50	181.50
1	2952.60	127.06	73.50	181.50
1	10251.80	235.55	181.50	289.50
1	8011.50	235.50	181.50	289.50
1	10273.80	343.50	289.50	397.50
1	10181.60	451.47	397.50	505.50
1	8027.70	451.50	397.50	505.50
1	9507.80	557.51	505.50	613.50
1	3906.60	559.22	505.50	613.50
1	100.00	720.87	715.00	726.00
1	500.00	623.65	613.50	633.75
1	500.00	623.74	613.50	633.75
1	30.70	739.30	735.00	745.00
1	95.60	655.70	613.50	700.00

BLOCK TYPE	SUMMARY WEIGHT (L.TONS)	SUMMARY LCG (FEET)
1	87448.12	363.21
TOTAL	87448.00	363.21

LONGITUDINAL GYRADIUS = 168.07 FEET

TABLE A.4

WEIGHT BLOCK DATA GENERAL CARGO SHIP

WEIGHT TYPE	BLOCK WEIGHT (L.TONS)	BLOCK LCG (FEET)	FWD END BLOCK (FEET)	AFT END BLOCK (FEET)
1	1067.70	441.53	393.94	505.43
1	104.74	392.07	390.75	393.38
1	2107.00	306.63	222.72	390.75
1	501.45	371.52	354.00	390.75
1	695.01	330.63	309.36	354.00
1	27.13	314.28	309.36	319.21
1	515.57	198.33	172.83	222.72
1	376.27	163.25	151.83	172.83
1	467.62	124.91	90.12	151.83
1	280.94	77.13	62.19	90.12
1	233.39	45.16	24.48	62.19
1	255.61	8.93	-13.13	24.48
1	1410.00	354.62	309.36	390.75
1	362.50	399.68	390.75	409.13
1	2100.60	134.56	89.19	162.33
1	2425.60	202.24	162.33	235.84
1	2425.60	272.01	235.84	309.36
1	930.00	329.91	309.36	354.00
1	280.00	380.91	375.00	388.13
1	905.00	328.20	309.36	353.90
1	294.00	364.17	356.62	372.38
1	411.00	8.91	-13.13	24.48
1	411.00	45.95	24.48	62.19
1	445.00	76.67	62.19	89.19

BLOCK TYPE	SUMMARY WEIGHT (L.TONS)	SUMMARY LCG (FEET)
1	19032.71	251.77
TOTAL	19032.68	251.77

LONGITUDINAL GYRADIUS = 113.28 FEET

TABLE A.5

STILLWATER SHEAR FORCE-BENDING MOMENT GENERAL CARGO SHIP

DISTANCE FROM FP (FEET)	WEIGHT FORCE	BUOYANCY FORCE (L.TONS)	SHEAR FORCE	WEIGHT MOMENT	BUOYANCY MOMENT (FEET -L.TONS)	BENDING MOMENT
-13.13	0.000E-01	1.511E-03	-.0	0.000E-01	8.593E-07	-.0
24.48	6.670E 02	2.240E 02	442.8	1.040E 04	3.460E 03	6914.2
62.19	1.310E 03	7.054E 02	605.5	4.620E 04	2.001E 04	26148.2
89.19	2.030E 03	1.270E 03	756.0	9.052E 04	4.620E 04	44317.5
90.12	2.044E 03	1.293E 03	751.6	9.241E 04	4.740E 04	45018.5
151.83	4.120E 03	3.483E 03	633.7	2.700E 05	1.881E 05	81471.6
162.33	4.770E 03	3.982E 03	786.1	3.161E 05	2.272E 05	88857.7
172.83	5.251E 03	4.520E 03	735.8	3.690E 05	2.720E 05	96812.0
222.72	7.400E 03	7.430E 03	-27.3	6.820E 05	5.674E 05	114060.2
235.84	8.090E 03	8.262E 03	-175.0	7.830E 05	6.703E 05	112707.8
309.36	1.143E 04	1.303E 04	-1598.3	1.502E 06	1.454E 06	48009.6
319.21	1.240E 04	1.364E 04	-1247.2	1.620E 06	1.590E 06	34031.6
353.90	1.520E 04	1.560E 04	-393.3	2.100E 06	2.093E 06	6755.7
354.00	1.520E 04	1.560E 04	-392.5	2.101E 06	2.100E 06	6716.4
356.62	1.532E 04	1.573E 04	-405.7	2.141E 06	2.140E 06	5670.2
372.38	1.640E 04	1.650E 04	-139.0	2.391E 06	2.390E 06	1356.1
375.00	1.650E 04	1.661E 04	-134.2	2.434E 06	2.433E 06	997.7
388.13	1.740E 04	1.720E 04	214.0	2.660E 06	2.660E 06	1625.0
390.75	1.750E 04	1.730E 04	236.4	2.702E 06	2.700E 06	2214.4
393.38	1.770E 04	1.740E 04	297.4	2.750E 06	2.750E 06	2915.4
393.94	1.770E 04	1.740E 04	288.3	2.760E 06	2.760E 06	3079.4
409.13	1.820E 04	1.790E 04	269.6	3.031E 06	3.023E 06	7269.3
505.43	1.903E 04	1.903E 04	.0	4.830E 06	4.830E 06	17.7

TABLE A.6

STILLWATER SHEAR FORCE-BENDING MOMENT 87,000 DWT TANKER

DISTANCE FROM FP (FEET)	WEIGHT FORCE	BUOYANCY FORCE (L.TONS)	SHEAR FORCE	WEIGHT MOMENT	BUOYANCY MOMENT (FEET-L.TONS)	BENDING MOMENT
-21.33	0.000E-01	0.000E-01	.0	0.000E-01	0.000E-01	.0
73.50	1.120E 03	4.180E 03	-3055.2	4.4243 -4	1.191E 05	-74941.5
181.50	1.460E 04	1.792E 04	-3342.2	8.581E 05	1.271E 06	-413284.3
235.50	2.462E 04	2.562E 04	-994.4	1.920E 06	2.450E 06	-529707.9
289.50	3.473E 04	3.333E 04	1402.8	3.520E 06	4.040E 06	-518731.9
397.50	4.704E 04	4.880E 04	-1723.0	7.940E 06	8.472E 06	-535979.8
424.50	5.212E 04	5.263E 04	-508.9	9.280E 06	9.841E 06	-566104.4
451.50	5.720E 04	5.650E 04	702.8	1.080E 07	1.131E 07	-563481.0
505.50	6.731E 04	6.420E 04	3122.3	1.411E 07	1.460E 07	-460336.9
613.50	8.270E 04	7.870E 04	4006.1	2.223E 07	2.231E 07	-77995.7
633.75	8.410E 04	8.091E 04	3171.2	2.392E 07	2.392E 07	-5862.9
700.00	8.550E 04	8.610E 04	-615.3	2.953E 07	2.950E 07	57810.7
715.00	8.580E 04	8.670E 04	-930.5	3.082E 07	3.080E 07	45949.3
726.00	8.610E 04	8.702E 04	-926.5	3.180E 07	3.173E 07	35594.0
735.00	8.630E 04	8.720E 04	-920.1	3.253E 07	3.251E 07	27226.7
745.00	8.652E 04	8.732E 04	-796.1	3.340E 07	3.340E 07	18594.7
788.50	8.744E 04	8.744E 04	-.0	3.720E 07	3.720E 07	2.8

TABLE A.7

STILLWATER SHEAR FORCE-BENDING MOMENT V . L . C . C .

DISTANCE FROM FP (FEET)	WEIGHT FORCE	BUOYANCY FORCE (L.TONS)	SHEAR FORCE	WEIGHT MOMENT	BUOYANCY MOMENT (FEET -L.TONS)	BENDING MOMENT
.00	0.000E-01	6.770E-02	-.1	0.000E-01	1.380E-04	-.0
78.83	1.660E 03	5.860E 03	-4195.2	5.591E 04	1.743E 05	-118428.6
81.35	1.710E 03	6.170E 03	-4460.3	6.020E 04	1.894E 05	-129333.3
173.30	9.791E 03	1.962E 04	-9837.4	5.852E 05	1.360E 06	-770158.5
280.71	2.982E 04	3.643E 04	-6615.3	2.750E 06	4.370E 06	-1619831.4
371.39	5.271E 04	5.070E 04	2023.9	6.510E 06	8.320E 06	-1807617.4
433.48	6.280E 04	6.050E 04	2305.6	1.010E 07	1.180E 07	-1668125.5
441.68	6.460E 04	6.180E 04	2811.5	1.062E 07	1.230E 07	-1646863.4
463.70	6.934E 04	6.522E 04	4120.9	1.210E 07	1.370E 07	-1569523.5
493.92	7.561E 04	7.000E 04	5620.6	1.430E 07	1.570E 07	-1421136.6
617.02	9.780E 04	8.932E 04	8435.3	2.500E 07	2.551E 07	-542153.9
647.87	1.003E 05	9.410E 04	6277.4	2.803E 07	2.834E 07	-314738.6
662.90	1.020E 05	9.640E 04	5326.0	2.960E 07	2.980E 07	-227178.3
678.55	1.030E 05	9.870E 04	4390.9	3.120E 07	3.130E 07	-150852.6
693.68	1.043E 05	1.010E 05	3536.8	3.272E 07	3.281E 07	-90604.0
708.77	1.060E 05	1.030E 05	2745.5	3.430E 07	3.440E 07	-43050.6
721.21	1.070E 05	1.050E 05	2381.6	3.563E 07	3.564E 07	-10903.1
721.28	1.070E 05	1.050E 05	2380.3	3.563E 07	3.564E 07	-10735.9
730.37	1.073E 05	1.060E 05	1692.5	3.661E 07	3.660E 07	7743.2
737.95	1.081E 05	1.064E 05	1653.9	3.742E 07	3.740E 07	20529.3
745.50	1.090E 05	1.073E 05	1578.0	3.824E 07	3.821E 07	32858.7
745.59	1.090E 05	1.073E 05	1576.5	3.830E 07	3.822E 07	33000.1
754.78	1.100E 05	1.083E 05	1275.3	3.930E 07	3.921E 07	46351.3
756.82	1.100E 05	1.090E 05	1160.3	3.950E 07	3.943E 07	48838.2
759.54	1.100E 05	1.090E 05	1021.0	3.980E 07	3.973E 07	51803.7
781.66	1.110E 05	1.110E 05	-59.6	4.222E 07	4.220E 07	61817.8
790.88	1.111E 05	1.114E 05	-329.5	4.324E 07	4.320E 07	59871.2
801.65	1.120E 05	1.121E 05	-661.7	4.444E 07	4.440E 07	54453.0
807.03	1.120E 05	1.124E 05	-730.2	4.504E 07	4.500E 07	50711.4
812.97	1.120E 05	1.130E 05	-798.5	4.570E 07	4.570E 07	46175.4
835.64	1.130E 05	1.140E 05	-958.0	4.830E 07	4.823E 07	25520.0
846.97	1.131E 05	1.140E 05	-898.3	4.953E 07	4.952E 07	14906.0
855.07	1.140E 05	1.141E 05	-588.7	5.050E 07	5.044E 07	9178.9
882.60	1.143E 05	1.143E 05	.7	5.360E 07	5.360E 07	561.7

TABLE A.8

STILLWATER SHEAR FORCE-BENDING MOMENT SL-7 CONTAINERSHIP

DISTANCE FROM FP (FEET)	WEIGHT FORCE	BUOYANCY FORCE (L.TONS)	SHEAR FORCE	WEIGHT MOMENT	BUOYANCY MOMENT (FEET -L.TONS)	BENDING MOMENT
-20.00	0.000E-01	0.000E-01	.0	0.000E-01	0.000E-01	.0
42.00	7.651E 02	3.341E 02	431.0	1.760E 04	6.580E 03	11024.5
115.25	2.612E 03	1.310E 03	1306.8	1.310E 05	6.290E 04	67924.7
167.75	3.820E 03	2.500E 03	1320.1	2.980E 05	1.603E 05	137230.3
207.75	5.431E 03	3.810E 03	1622.5	4.862E 05	2.852E 05	200997.5
247.75	7.380E 03	5.530E 03	1845.0	7.470E 05	4.710E 05	276161.8
287.75	9.754E 03	7.694E 03	2060.5	1.094E 06	7.340E 05	361046.0
327.75	1.210E 04	1.031E 04	1746.6	1.540E 06	1.092E 06	443787.2
367.75	1.470E 04	1.340E 04	1315.1	2.080E 06	1.564E 06	512125.4
407.75	1.781E 04	1.674E 04	1079.2	2.733E 06	2.170E 06	568049.6
447.75	2.120E 04	2.040E 04	799.5	3.520E 06	2.910E 06	613768.1
492.75	2.450E 04	2.460E 04	-94.9	4.554E 06	3.920E 06	637270.1
537.75	2.764E 04	2.873E 04	-1092.1	5.734E 06	5.120E 06	617514.7
562.75	3.093E 04	3.101E 04	-75.6	6.470E 06	5.863E 06	603654.7
612.75	3.400E 04	3.540E 04	-1419.2	8.090E 06	7.524E 06	565815.9
652.75	3.663E 04	3.862E 04	-1992.6	9.500E 06	9.010E 06	490525.7
697.75	3.953E 04	4.181E 04	-2284.4	1.121E 07	1.081E 07	394730.3
737.75	4.170E 04	4.413E 04	-2479.1	1.284E 07	1.253E 07	301123.7
777.75	4.332E 04	4.590E 04	-2550.1	1.454E 07	1.434E 07	200876.3
817.75	4.492E 04	4.710E 04	-2124.7	1.631E 07	1.620E 07	108989.9
852.50	4.620E 04	4.760E 04	-1412.1	1.790E 07	1.784E 07	45789.2
880.50	4.710E 04	4.773E 04	-664.9	1.920E 07	1.920E 07	13545.8
920.50	4.780E 04	4.780E 04	-.1	2.110E 07	2.110E 07	-73.6

TABLE A.9

HYDROSTATIC PROPERTIES SL-7 CONTAINERSHIP

STATION FROM F.P.	MEAN DRAFT (FEET)	WL WIDTH (FEET)	AREA (FEET **2)	AREA COEF.	VCB (FEET)	HCB (FEET)
.0000	32.5699	.0000	223.395	.48429	10.2857	.0000
11.0063	32.5745	2.1638	255.815	.54340	11.6938	.0000
22.0125	32.5790	2.9777	278.611	.56464	12.2748	.0000
44.0250	32.5882	6.0038	338.160	.62984	13.4453	.0000
66.0375	32.5973	9.9153	404.645	.69719	14.5747	.0000
88.0500	32.6065	15.8740	496.152	.77876	15.7666	.0000
110.0625	32.6156	21.9401	598.253	.83603	16.8398	.0000
132.0750	32.6247	29.0314	720.743	.76097	17.6055	.0000
176.1000	32.6430	44.8291	1042.539	.71243	18.5956	.0000
220.1250	32.6613	60.5690	1429.847	.72278	18.8042	.0000
264.1499	32.6796	75.1529	1853.995	.75489	18.5735	.0000
308.1750	32.6979	87.5073	2298.710	.80338	18.2212	.0000
352.2000	32.7161	97.0772	2707.913	.85262	17.8107	.0000
396.2251	32.7344	103.1746	3024.783	.89561	17.4792	.0000
440.2500	32.7527	105.4990	3228.762	.93442	17.2007	.0000
484.2749	32.7710	105.5000	3275.950	.94753	17.1028	.0000
528.3000	32.7893	105.5000	3235.659	.93536	17.2381	.0000
572.3250	32.8076	105.5000	3134.844	.90571	17.5513	.0000
616.3501	32.8259	105.5000	2944.643	.85028	18.0879	.0000
660.3750	32.8441	103.2455	2634.237	.77683	18.8791	.0000
704.3999	32.8624	95.5639	2183.578	.69531	19.8335	.0000
748.4250	32.8807	83.7275	1649.705	.59923	20.8927	.0000
770.4375	32.8899	75.4687	1368.520	.55134	21.4471	.0000
792.4500	32.8990	66.8890	1089.531	.49511	22.0516	.0000
814.4624	32.9081	56.2330	817.643	.44184	22.5909	.0000
836.4751	32.9173	44.8577	504.602	.51380	25.0231	.0000
858.4875	32.9264	32.6187	261.052	.48439	27.0737	.0000
869.4939	32.9310	26.1971	149.252	.57172	29.0967	.0000
880.5000	32.9356	19.0914	77.053	.60340	30.3150	.0000
902.5125	32.9447	6.0119	7.320	.50047	32.1337	.0000

LIMIT OF UNDERWATER AREA	.00 TO 902.51	FEET
LIMIT OF WATERPLANE AREA	.00 TO 902.51	FEET
VOLUME (MLD.)	1670491.0	FEET **3
DISPLACEMENT (MLD.)	47759.870	L.TONS
BLOCK COEFFICIENT (MLD.)	.549060	
HALF-AREA MIDSHIP SECTION	1614.381	FEET **2
MIDSHIP SECTION COEFFICIENT	.934416	
PRISMATIC COEFFICIENT (MLD.)	.587596	
TRIM	.366	FEET
HEEL	.000	DEGREES
VCB (FROM B.L.)	18.214	FEET
HCB (FROM C.L.)	.000	FEET
LCB (FROM F.P.)	478.868	FEET
BM,TRANSVERSE	26.903	FEET
BM,LONGITUDINAL	1462.644	FEET
MOMENT TO ALTER TRIM 0.1 FEET	7933.637	
L.TONS PER 0.1 FEET IMMERSION	183.376	
AREA OF WATERPLANE	64139.090	FEET **2
WATERPLANE COEFFICIENT (MLD.)	.690471	
L.C.F. FROM F.P.	501.293	FEET
CHANGE IN DISPL. FOR 1 FEET TRIM AFT	-127.131	L.TONS
WETTED SURFACE (MLD.)	99864.060	FEET **2

TABLE A.10

HYDROSTATIC PROPERTIES V . L . C . C .

STATION FROM F.P.	MEAN DRAFT (FEET)	WL WIDTH (FEET)	AREA (FEET **2)	AREA COEF.	VCB (FEET)	HCB (FEET)
.0000	43.3957	14.7659	582.044	.78877	25.7239	.0000
21.9894	43.4039	48.6943	1771.048	.83796	24.0961	.0000
43.9788	43.4121	77.2503	2909.215	.86749	23.4825	.0000
65.9682	43.4203	99.1758	3888.847	.90307	22.9804	.0000
87.9576	43.4285	114.2252	4611.031	.92952	22.6935	.0000
131.9364	43.4450	126.6851	5314.922	.96568	22.2602	.0000
175.9152	43.4614	127.7735	5463.980	.98204	22.0254	.0000
219.8940	43.4778	127.6698	5468.488	.98248	22.0289	.0000
263.8726	43.4942	127.6698	5485.047	.98508	21.9892	.0000
307.8516	43.5106	127.6698	5499.066	.98723	21.9647	.0000
351.8303	43.5270	127.6698	5501.160	.98723	21.9729	.0000
395.8091	43.5434	127.6698	5503.254	.98724	21.9811	.0000
439.7878	43.5598	127.6698	5505.352	.98724	21.9894	.0000
483.7666	43.5762	127.6698	5522.953	.99002	21.9469	.0000
527.7454	43.5926	127.6698	5491.746	.98406	22.0624	.0000
571.7241	43.6090	127.7354	5487.191	.98506	22.0893	.0000
615.7031	43.6254	127.7742	5489.391	.98290	22.1009	.0000
659.6819	43.6418	127.6698	5313.180	.95359	22.5183	.0000
703.6606	43.6582	123.9964	4732.824	.87427	23.3615	.0000
747.6394	43.6746	109.9180	3757.344	.78268	24.2271	.0000
791.6182	43.6910	87.1898	2507.529	.65825	25.3643	.0000
813.6077	43.6992	72.2416	1816.665	.57546	26.0871	.0000
835.5969	43.7074	55.6954	1085.222	.44580	27.8012	.0000
857.5864	43.7156	37.3049	366.591	.26451	34.8016	.0000
879.5757	43.7238	17.9889	71.404	.36403	41.1150	.0000

LIMIT OF UNDERWATER AREA	.00 TO 879.58	FEET
LIMIT OF WATERPLANE AREA	.00 TO 879.58	FEET
VOLUME (MLD.)	4000170.0	FEET **3
DISPLACEMENT (MLD.)	114366.100	L.TONS
BLOCK COEFFICIENT (MLD.)	.815537	
HALF-AREA MIDSHIP SECTION	2752.676	FEET **2
MIDSHIP SECTION COEFFICIENT	.987241	
PRISMATIC COEFFICIENT (MLD.)	.826076	
TRIM	.328	FEET
HEEL	.000	DEGREES
VCB (FROM B.L.)	22.489	FEET
HCB (FROM C.L.)	.000	FEET
LCB (FROM F.P.)	413.976	FEET
BM,TRANSVERSE	30.185	FEET
BM,LONGITUDINAL	1281.203	FEET
MOMENT TO ALTER TRIM 0.1 FEET	16658.740	
L.TONS PER 0.1 FEET IMMERSION	282.572	
AREA OF WATERPLANE	98835.000	FEET **2
WATERPLANE COEFFICIENT (MLD.)	.877731	
L.C.F. FROM F.P.	428.910	FEET
CHANGE IN DISPL. FOR 1 FEET TRIM AFT	34.947	L.TONS
WETTED SURFACE (MLD.)	158492.700	FEET **2

TABLE A.11

HYDROSTATIC PROPERTIES

87,000 DWT TANKER

STATION FROM F.P.	MEAN DRAFT (FEET)	WL WIDTH (FEET)	AREA (FEET **2)	AREA COEF.	VCB (FEET)	HCB (FEET)
-20.0830	40.0784	.0000	31.993	.18974	12.7693	.0000
-16.5000	40.0788	.0000	162.859	.36939	12.8849	.0000
-10.5000	40.0795	.0000	262.360	.47443	13.0758	.0000
-4.5000	40.0801	.0000	343.031	.53274	13.9704	.0000
.0000	40.0806	1.8340	436.023	.62759	15.9582	.0000
9.5375	40.0817	16.1068	708.657	.80976	19.7549	.0000
19.0750	40.0828	31.1216	1092.383	.87570	21.3450	.0000
28.6125	40.0838	45.7733	1545.001	.84207	21.8209	.0000
38.1500	40.0849	59.0971	2003.908	.84592	21.8928	.0000
57.2250	40.0870	81.9147	2847.314	.86710	21.7127	.0000
76.3000	40.0891	99.2126	3521.727	.88545	21.4969	.0000
114.4500	40.0933	118.8518	4452.184	.93432	20.9448	.0000
152.6000	40.0975	124.7004	4854.539	.97087	20.4723	.0000
190.7500	40.1018	125.0000	4976.992	.99287	20.1778	.0000
228.9000	40.1060	125.0000	4997.078	.99677	20.1134	.0000
267.0500	40.1102	125.0000	4997.605	.99678	20.1155	.0000
305.2000	40.1144	125.0000	4998.133	.99678	20.1177	.0000
343.3501	40.1187	125.0000	4998.664	.99678	20.1198	.0000
381.5000	40.1229	125.0000	4999.191	.99678	20.1219	.0000
419.6499	40.1271	125.0000	4999.719	.99678	20.1240	.0000
457.8000	40.1313	125.0000	5000.246	.99678	20.1261	.0000
495.9500	40.1356	125.0000	4988.094	.99425	20.1733	.0000
534.1001	40.1398	125.0000	4903.008	.97719	20.4417	.0000
572.2500	40.1440	125.0000	4690.945	.93482	21.0344	.0000
610.3999	40.1482	123.5446	4183.379	.84341	21.9636	.0000
648.5500	40.1525	113.6434	3301.611	.72355	23.2874	.0000
686.7000	40.1567	93.1442	2139.639	.57204	25.1894	.0000
705.7749	40.1588	79.5003	1501.597	.47033	26.5552	.0000
724.8501	40.1609	63.8812	882.656	.34404	28.5766	.0000
734.3875	40.1620	55.4513	572.595	.25711	30.6101	.0000
743.9250	40.1630	46.5469	281.155	.58007	36.5557	.0000
753.4624	40.1641	37.5632	181.852	.60538	37.1997	.0000
763.0000	40.1651	28.2644	108.828	.57059	37.7441	.0000
773.0000	40.1662	17.6290	45.418	.54248	38.5130	.0000
788.5000	40.1680	6.8276	6.755	.51585	39.5256	.0000

LIMIT OF UNDERWATER AREA	-20.08 TO 788.50	FEET
LIMIT OF WATERPLANE AREA	-4.50 TO 788.50	FEET
VOLUME (MLD.)	3058660.0	FEET **3
DISPLACEMENT (MLD.)	87448.060	L.TONS
BLOCK COEFFICIENT (MLD.)	.799290	
HALF-AREA MIDSHIP SECTION	2499.596	FEET **2
MIDSHIP SECTION COEFFICIENT	.996776	
PRISMATIC COEFFICIENT (MLD.)	.801875	
TRIM	.084	FEET
HEEL	.000	DEGREES
VCB (FROM B.L.)	20.832	FEET
HCB (FROM C.L.)	.000	FEET
LCB (FROM F.P.)	363.209	FEET
BM,TRANSVERSE	31.823	FEET
BM,LONGITUDINAL	1076.620	FEET
MOMENT TO ALTER TRIM 0.1 FEET	12339.230	
L.TONS PER 0.1 FEET IMMERSION	239.939	
AREA OF WATERPLANE	83923.000	FEET **2
WATERPLANE COEFFICIENT (MLD.)	.879927	
L.C.F. FROM F.P.	384.663	FEET
CHANGE IN DISPL. FOR 1 FEET TRIM AFT	-9.947	L.TONS
WETTED SURFACE (MLD.)	132002.700	FEET **2

TABLE A.12

HYDROSTATIC PROPERTIES GENERAL CARGO SHIP

STATION FROM F.P.	MEAN DRAFT (FEET)	WL WIDTH (FEET)	AREA (FEET **2)	AREA COEF.	VCB (FEET)	HCB (FEET)
-13.1280	31.4663	.0000	46.296	.25742	7.7878	.0000
-11.4870	31.4674	.0000	83.481	.31831	7.8309	.0000
-9.8460	31.4686	.0000	109.341	.36273	7.9149	.0000
-6.5640	31.4710	.0000	145.220	.41206	8.4176	.0000
-3.2820	31.4733	.0000	166.629	.44390	8.8139	.0000
.0000	31.4756	.5988	187.214	.48457	9.9550	.0000
12.3075	31.4844	3.8548	243.961	.60228	12.5433	.0000
24.6150	31.4932	7.9440	315.345	.74961	14.3091	.0000
36.9225	31.5020	12.4938	393.255	.84525	15.5423	.0000
49.2300	31.5107	17.4905	484.880	.87978	16.3846	.0000
73.8450	31.5283	28.8525	706.431	.77658	17.3981	.0000
98.4600	31.5459	40.7362	972.023	.75640	17.8476	.0000
123.0750	31.5634	52.0587	1265.804	.77035	17.8849	.0000
147.6900	31.5810	61.8071	1560.503	.79947	17.7012	.0000
172.3050	31.5985	69.0707	1827.276	.83723	17.3855	.0000
196.9200	31.6161	73.5795	2050.693	.88153	17.0194	.0000
221.5350	31.6337	75.1878	2206.068	.92752	16.6758	.0000
246.1500	31.6512	75.2562	2288.367	.96071	16.3773	.0000
270.7649	31.6688	75.2562	2302.966	.96630	16.3185	.0000
295.3799	31.6863	75.2562	2251.062	.94400	16.5736	.0000
319.9949	31.7039	75.2213	2118.963	.88853	17.0772	.0000
344.6099	31.7214	73.8192	1905.177	.81360	17.6862	.0000
369.2249	31.7390	69.5598	1630.136	.73837	18.3253	.0000
393.8398	31.7566	62.0977	1297.478	.65795	18.9384	.0000
418.4548	31.7741	51.6544	936.515	.57060	19.6127	.0000
443.0698	31.7917	38.9672	565.939	.45683	20.4726	.0000
455.3774	31.8005	32.1439	382.999	.37468	21.2833	.0000
467.6848	31.8092	25.3115	203.559	.25283	23.3246	.0000
479.9924	31.8180	18.5598	67.830	.51205	29.4181	.0000
492.2998	31.8268	11.6059	29.873	.54186	30.1588	.0000
498.8638	31.8315	7.3023	12.135	.56337	30.7674	.0000
505.4277	31.8362	.0021	.000	.49977	31.8359	.0000

LIMIT OF UNDERWATER AREA	-13.13 TO	505.43	FEET
LIMIT OF WATERPLANE AREA	-3.28 TO	505.43	FEET
VOLUME (MLD.)		665702.9	FEET **3
DISPLACEMENT (MLD.)		19032.660	L.TONS
BLOCK COEFFICIENT (MLD.)		.568216	
HALF-AREA MIDSHIP SECTION		1103.034	FEET **2
MIDSHIP SECTION COEFFICIENT		.927003	
PRISMATIC COEFFICIENT (MLD.)		.612960	
TRIM		.351	FEET
HEEL		.000	DEGREES
VCB (FROM B.L.)		17.338	FEET
HCB (FROM C.L.)		.000	FEET
LCB (FROM F.P.)		251.773	FEET
BM,TRANSVERSE		13.929	FEET
BM,LONGITUDINAL		481.860	FEET
MOMENT TO ALTER TRIM 0.1 FEET		1862.903	
L.TONS PER 0.1 FEET IMMERSION		74.492	
AREA OF WATERPLANE		26054.850	FEET **2
WATERPLANE COEFFICIENT (MLD.)		.703901	
L.C.F. FROM F.P.		266.269	FEET
CHANGE IN DISPL. FOR 1 FEET TRIM AFT		-30.443	L.TONS
WETTED SURFACE (MLD.)		48066.040	FEET **2

ATTACHMENT B

Summary of Dynamic Response Predictions

INDEX OF ATTACHMENT B

TABLE B.I

WAVE INDUCED BENDING MOMENT

	SL-7	VLCC	TANKER	GENERAL CARGO
LENGTH(ft)	880.5	879.6	763.0	492.30
BEAM(ft)	105.0	127.74	125.0	75.26
DEPTH(ft)	64.0	66.79	54.5	43.49
Cb	.549	.816	.799	.568
SPEED(knots)	30.0	16.0	16.5	16.0
WAVE-INDUCED BENDING MOMENT @ (L.TONS.FT)				
ABS	1,095,026	1,528,516	1,058,063	191,381
LLOYD'S	982,671	1,446,681	1,017,541	188,166
DNV	982,666	1,447,870	1,014,457	188,311
HINDCAST EXCEEDANCE:				
Hindcast Spectra	1,403,000	2,632,100	1,621,400	167,600
Station INDIA	1,574,000	2,807,100	1,778,000	190,310
ISSC Spectra	1,402,000	2,603,000	1,614,000	167,600
MEASURED EXCEEDANCE:				
Hindcast Spectra	1,263,100	2,375,000	1,448,000	157,400
Station INDIA	1,444,000	2,578,000	1,633,300	176,700
ISSC Spectra	1,246,400	2,274,000	1,423,200	154,300
OBSERVED EXCEEDANCE:				
Hindcast Spectra	1,094,200	1,965,200	1,239,000	150,440
Station INDIA	1,238,000	2,187,100	1,394,100	162,920
ISSC Spectra	1,081,400	1,936,000	1,224,400	143,720

TABLE B.2

SL7 CONTAINERSHIP, FULL LOAD
30 KNOTS, EQUAL PROBABILITY OF HEADING

HIGHEST RESPONSE IN 20-YEAR PERIOD

LOCATION	VERTICAL BENDING MOMENT □ FT-L.TONS	VERTICAL SHEAR FORCE □ L. TONS	VERTICAL ACCEL. @ BOW FT/S2	VERTICAL ACCEL. .2L AFT OF FP FT/S2	VERTICAL ACCEL. □ FT/S2	LATERAL ACCEL. TOP OF CARGO □ FT/S2
G037S9	1661200	4891	84.6	60.8	31.1	9.4
G045S2	1872400	5365	95.2	68.5	35.1	10.7
G056S3	1782000	5065	90.3	65.0	33.4	10.2
G102S3	1772000	5080	89.7	64.5	33.3	10.4
G105S9	1785000	5172	90.2	64.9	33.3	10.2
G114S2	1872000	5324	95.3	68.5	35.2	10.7
G124S9	1828000	5201	93.4	67.2	34.3	10.4
G128S9	1874000	5254	94.1	67.8	35.2	11.2
G181S9	1798000	5309	92.2	66.1	33.5	10.2
G184S9	1774000	5118	89.9	64.7	33.2	10.3
G187S9	1864000	5264	94.4	67.9	34.9	10.8
G216S3	1766300	5095	89.5	64.4	33.1	10.2
G272S7	1677000	4953	86.0	61.8	31.6	9.5
G275S7	1824000	5257	92.6	66.6	34.1	10.5
G278S7	1918100	5538	97.9	70.4	36.0	10.8

TABLE B.3

SL7 CONTAINERSHIP, FULL LOAD
30 KNOTS, EQUAL PROBABILITY OF HEADING

HIGHEST ROLL DISPLACEMENT (DEGREES) IN ONE YEAR

	- WAVE HEIGHT -									
LOCATION	0-3	3-6	6-9	9-12	12-16	16-21	21-27	27-32	32-40	40-50
G037S9	4.68	8.88	12.84	16.71	20.55	32.61	42.38	53.52	59.41	66.97
G045S2	4.91	7.76	12.26	17.65	23.04	33.35	41.68	51.99	62.47	69.87
G056S3	3.70	9.09	13.49	17.47	23.81	32.98	40.75	51.28	59.65	68.14
G102S3	4.25	8.33	12.73	17.64	24.42	32.54	43.26	50.40	57.68	66.94
G105S9	4.38	8.93	12.47	17.10	25.19	32.93	42.90	53.05	59.12	70.51
G114S2	3.94	9.36	13.42	16.83	24.07	31.54	42.47	51.75	61.10	69.61
G124S9	3.01	8.45	12.19	15.68	23.36	33.61	43.22	52.60	61.94	73.58
G128S9	4.32	9.13	12.68	18.09	22.47	30.35	43.54	47.90	59.56	67.92
G181S9	4.52	7.78	12.32	16.90	24.13	30.85	42.06	49.24	55.80	68.15
G184S9	5.05	8.24	13.32	17.75	21.99	31.57	41.04	49.71	60.33	67.55
G187S9	3.91	7.91	14.18	16.63	23.78	33.96	44.38	50.11	61.43	68.78
G216S3	4.93	9.36	13.12	17.49	24.24	29.53	41.83	50.47	59.37	65.99
G272S7	3.58	7.30	12.09	18.39	21.59	33.19	42.91	49.82	58.06	66.82
G275S7	4.34	8.57	12.73	16.43	25.97	32.17	43.33	50.53	60.57	70.01
G278S7	4.84	8.01	12.34	15.98	23.15	32.42	41.79	52.94	62.36	71.82

NOTE: indicates improbable operating condition

TABLE B.4

SL7 CONTAINERSHIP, FULL LOAD
30 KNOTS, EQUAL PROBABILITY OF HEADING

HIGHEST EXPECTED WAVE INDUCED VERTICAL BENDING MOMENT 0
IN ONE YEAR (FT-L.TONS)

	- WAVE HEIGHT -									
LOCATION	0-3	3-6	6-9	9-12	12-16	16-21	21-27	27-32	32-40	40-50
G037S9	102000	204300	310500	388700	461700	756910	996200	1257400	1370000	1494300
G045S2	97551	185940	290220	413400	526840	778100	966800	1221400	1437000	1574400
G056S3	78950	212330	333140	411230	549100	758100	939400	1195000	1373000	1529000
G102S3	98862	191340	304440	567100	567100	751340	1002400	1170000	1320000	1495000
G105S9	87440	213040	303500	389910	581800	760400	1005000	1241000	1367000	1565000
G114S2	95311	222420	329400	389000	555730	724310	988130	1206300	1408000	1570100
G124S9	68141	195700	275320	459040	524900	779200	1003000	1213000	1426200	1635000
G128S9	101130	219940	305310	424230	514900	696410	1005300	1109000	1354100	1516000
G181S9	101140	205800	293300	387830	553900	705210	969940	1138000	1264300	1567000
G184S9	105600	186100	318800	413000	504500	722500	945500	1151200	1371000	1514000
G187S9	87650	186600	338730	381700	553140	783900	1028000	1169300	1408000	1537000
G216S3	105900	236240	313900	406800	556340	673400	966620	1165200	1348300	1482000
G272S7	83601	170600	290020	449520	495400	766040	1004300	1155000	1315000	1490000
G275S7	90130	190600	303100	377800	613500	744210	1006000	1178000	1380000	1565300
G278S7	101300	182600	305900	366900	528500	740900	970600	1234000	1434000	1612100

NOTE: indicates improbable operating condition

TABLE B.5

SL7 CONTAINERSHIP, FULL LOAD
30 KNOTS, EQUAL PROBABILITY OF HEADING

HIGHEST VERTICAL SHEAR FORCE @ IN ONE YEAR (L. TONS)

	- WAVE HEIGHT -									
LOCATION	0-3	3-6	6-9	9-12	12-16	16-21	21-27	27-32	32-40	40-50
G037S9	360.6	738.8	992.4	1432.0	1825.0	2785.4	3489.2	4080.0	4201.4	4349.0
G045S2	417.7	666.6	1047.1	1484.0	1882.1	2818.0	3308.0	4125.3	4602.0	4802.0
G056S3	377.9	785.8	1137.3	1411.0	1875.4	2637.4	3196.1	3873.4	4174.0	4445.0
G102S3	403.0	710.6	1013.0	1403.0	1909.4	2516.4	3329.1	3831.2	4021.3	4396.1
G105S9	345.3	773.0	1109.0	1399.0	2034.0	2762.0	3444.2	4068.0	4172.0	4540.2
G114S2	387.8	769.8	1124.4	1431.4	2002.0	2534.0	3433.3	3950.1	4371.1	4640.0
G124S9	230.0	669.2	1108.0	1383.2	1997.1	2301.0	3360.3	3831.0	4354.1	4675.0
G128S9	396.3	802.8	1129.3	1438.0	1782.0	2522.0	3382.1	3652.1	4137.0	4408.1
G181S9	356.3	634.0	1054.3	1384.1	1955.0	2435.4	3207.0	3696.2	3840.0	4674.2
G184S9	409.1	707.2	1106.0	1402.2	1865.0	2513.4	3240.3	3739.0	4175.2	4436.3
G187S9	391.4	712.1	1200.0	1401.0	1837.3	2701.3	3445.0	3855.0	4255.4	4449.0
G216S3	414.8	824.7	1088.0	1481.0	1899.1	2452.3	3198.0	3705.0	4123.0	4360.0
G272S7	285.2	660.0	1064.0	1542.0	1879.2	2776.1	3606.6	3803.4	4058.2	4394.0
G275S7	367.6	739.3	1081.0	1304.0	2154.0	2731.0	3419.2	3869.3	4223.2	4546.1
G278S7	413.2	771.5	1044.2	1390.3	1837.0	2603.2	3363.0	4077.0	4395.0	4706.1

NOTE: indicates improbable operating condition.

TABLE B.6

SL7 CONTAINERSHIP, FULL LOAD
30 KNOTS, EQUAL PROBABILITY OF HEADING

HIGHEST VERTICAL ACCELERATION
@ BOW IN ONE YEAR (FT/S2)

LOCATION	- WAVE HEIGHT -									
	0-3	3-6	6-9	9-12	12-16	16-21	21-27	27-32	32-40	40-50
G037S9	4.90	9.70	17.10	21.00	23.00	38.10	51.20	65.90	71.20	76.20
G045S2	4.42	9.36	14.98	21.49	27.18	39.20	49.91	64.18	75.03	81.07
G056S3	3.67	9.89	16.80	21 28	29.14	38.72	48.24	62.39	71.43	78.35
G102S3	4.44	9.18	16.28	21.78	29.68	39.49	51.99	60.99	68.36	76.42
G105S9	4.12	10.38	15.48	19.68	29.80	38.37	52.14	64.20	71.50	79.39
G114S2	4.79	10.92	17.51	20.70	28.55	37.57	51.01	63.05	73.21	80.72
G124S9	3.70	9.62	13.60	17.56	25.72	40.31	51.44	62.66	74.21	83.87
G128S9	4.85	10.52	15.25	21.88	26.99	34.94	51.61	57.14	69.88	77.44
G181S9	4.84	10.49	15.31	20.97	28.58	35.97	49.79	58.42	65.04	81.08
G184S9	5.08	9.77	16.41	21.51	26.53	37.07	48.26	59.82	70.72	77.77
G187S9	4.03	9.34	16.18	20.11	28.72	40.40	52.71	60.90	73.27	78.67
G216S3	4.93	12.02	16.08	20.99	28.50	33.92	49.80	60.37	69.51	75.88
G272S7	4.22	8.29	15.12	23.39	25.38	38.83	51.42	59.61	67.29	76.61
G275S7	4.10	9.15	14.68	19.87	31.73	37.01	52.11	61.44	71.41	80.23
G278S7	4.70	8.60	15.79	18.33	27.75	36.90	49.79	64.50	74.64	82.76

NOTE: indicates improbable operating condition.

TABLE B.7

SL7 CONTAINERSHIP, FULL LOAD
30 KNOTS, EQUAL PROBABILITY OF HEADING

HIGHEST ACCELERATION Ø
(TOP OF CONTAINERS)
IN ONE YEAR (FT/S2)

	- WAVE HEIGHT -									
LOCATION	0-3	3-6	6-9	9-12	12-16	16-21	21-27	27-32	32-40	40-50
G037S9	.73	1.38	1.70	2.55	3.28	4.72	5.69	6.86	7.52	8.48
G045S2	.82	1.19	1.93	2.67	3.52	4.77	5.57	6.72	7.84	6.79
G056S3	.68	1.44	1.88	2.50	3.45	4.61	5.45	6.58	7.53	8.63
G102S3	.72	1.36	1.76	2.56	3.45	4.38	5.69	6.56	7.34	8.53
G105S9	.71	1.38	2.05	2.64	3.63	4.71	5.67	6.79	7.43	8.99
G114S2	.69	1.41	1.97	2.65	3.63	4.53	5.74	6.68	7.74	8.80
G124S9	.46	1.25	2.08	2.64	3.70	4.61	5.76	6.77	7.78	9.33
G128S9	.72	1.34	2.00	2.63	3.33	4.37	5.81	6.32	7.58	8.63
G181S9	.69	.94	1.95	2.57	3.53	4.28	5.55	6.41	7.13	8.49
G184S9	.82	1.32	1.97	2.58	3.44	4.46	5.57	6.46	7.69	8.57
G187S9	.74	1.33	2.17	2.63	3.30	4.71	5.89	6.52	7.73	8.72
G216S3	.81	1.40	1.94	2.69	3.47	4.37	5.59	6.51	7.58	8.39
G272S7	.54	1.18	1.94	2.64	3.50	4.71	5.81	6.49	7.46	8.54
G275S7	.72	1.36	1.89	2.48	3.73	4.64	5.78	6.55	7.69	8.90
G278S7	.81	1.39	1.85	2.60	3.44	4.66	5.62	6.83	7.87	9.06

NOTE: indicates improbable operating condition.

TABLE B.8

SL7 CONTAINERSHIP, FULL LOAD
30 KNOTS

HIGHEST ROLL DISPLACEMENT (DEGREES) IN ONE YEAR
(16-21 FOOT WAVE HEIGHT)

	- HEADING -						
LOCATION/ SPEED	0 DEG	30 DEG	60 DEG	90 DEG	120 DEG	150 DEG	180 DEG
G045S2:							
0 KNOTS	34.90	35.61	35.11	36.71	11.96	2.18	2.18
10 KNOTS	34.55	35.27	35.30	26.41	11.86	2.18	2.18
20 KNOTS	34.11	34.83	34.36	26.17	11.74	2.18	2.18
25 KNOTS	33.84	34.56	34.10	25.98	11.67	2.18	2.18
30 KNOTS	33.52	34.24	33.80	25.77	11.60	2.18	2.18
G128S9:							
0 KNOTS	31.41	32.14	31.81	24.32	11.04	2.08	2.08
10 KNOTS	31.14	31.87	31.55	24.13	10.96	2.08	2.08
20 KNOTS	30.78	31.53	31.22	23.88	10.87	2.08	2.08
25 KNOTS	30 57	31.32	31.01	23.73	10.82	2.08	2.08
30 KNOTS	30.31	31.07	30.77	23.56	10.76	2.08	2.08

TABLE B.9

SL7 CONTAINERSHIP, FULL LOAD
30 KNOTS

HIGHEST EXPECTED WAVE INDUCED VERTICAL BENDING MOMENT
IN ONE YEAR (FT-L.TONS)
(16-21 FT WAVE HEIGHT)

	- HEADING -						
LOCATION/ SPEED	0 DEG	30 DEG	60 DEG	90 DEG	120 DEG	150 DEG	180 DEG
G045S2:							
0 KNOTS	548300	539520	521710	534200	640230	787400	852700
10 KNOTS	541700	533600	522020	534400	644900	794700	860900
20 KNOTS	533000	525940	513900	535420	649040	800700	867530
25 KNOTS	527610	521500	512240	536230	651000	803340	870410
30 KNOTS	522120	516940	511100	537200	652800	805800	873100
G128S9:							
0 KNOTS	493430	485940	471140	480600	568000	697900	756600
10 KNOTS	488430	481400	467840	480700	571600	703540	763000
20 KNOTS	481800	475130	464600	481600	574900	708200	768200
25 KNOTS	477400	471500	463300	482230	576400	710230	770500
30 KNOTS	472910	467800	462320	483000	577800	712130	772510

TABLE B.10

SL7 CONTAINERSHIP, FULL LOAD
30 KNOTS

HIGHEST VERTICAL SHEAR FORCE Ø
IN ONE YEAR (L.TONS)
(16-21 FT WAVE HEIGHT)

- HEADING -

LOCATION/ SPEED	0 DEG	30 DEG	60 DEG	90 DEG	120 DEG	150 DEG	180 DEG
G045S2:							
0 KNOTS	2193.0	2169.2	2133.2	2119.0	2407.0	2881.1	3084.0
10 KNOTS	2162.0	2140.0	2120.0	2114.0	2423.1	2909.1	3116.0
20 KNOTS	2116.0	2099.1	2087.2	2114.1	2438.4	2932.1	3141.0
25 KNOTS	2090.0	2076.1	2078.0	2116.4	2446.0	2942.1	3152.1
30 KNOTS	2076.0	2061.1	2073.2	2120.0	2453.0	2951.4	3162.4
G128S9:							
0 KNOTS	2050.0	2007.4	1979.0	1951.4	2166.4	2563.0	2738.0
10 KNOTS	1998.0	1982.4	1960.0	1947.1	2180.0	2585.2	2763.0
20 KNOTS	1960.0	1948.4	1940.3	1947.3	2192.0	2603.3	2783.0
25 KNOTS	1938.0	1929.1	1932.4	1949.1	2198.3	2611.3	2791.2
30 KNOTS	1927.0	1917.0	1928.3	1952.0	2204.0	2619.0	2799.3

TABLE B.11

SL7 CONTAINERSHIP, FULL LOAD
30 KNOTS

HIGHEST VERTICAL ACCELERATION @ BOW IN ONE YEAR (FT/S2)

(16-21 FT WAVE HEIGHT)

LOCATION/ SPEED	- HEADING - 0 DEG	30 DEG	60 DEG	90 DEG	120 DEG	150 DEG	180 DEG
G045S2:							
0 KNOTS	2.44	5.91	16.12	28.06	36.59	40.49	41.41
10 KNOTS	2.44	5.92	15.71	28.21	36.83	40.80	41.75
20 KNOTS	2.44	5.93	16.24	28.34	37.03	41.07	41.04
25 KNOTS	2.44	5.94	16.27	28.41	37.13	41.19	42.17
30 KNOTS	2.44	5.95	16.29	28.47	37.22	41.31	42.29
G128S9:							
0 KNOTS	2.33	7.03	14.66	25.01	32.18	35.76	36.90
10 KNOTS	2.33	7.04	14.71	25.13	32.37	36.00	37.18
20 KNOTS	2.33	7.06	14.76	25.24	32.53	36.21	37.41
25 KNOTS	2.33	7.07	14.78	25.30	32.61	36.30	37.51
30 KNOTS	2.33	7.08	14.80	25.34	32.68	36.39	37.60

TABLE B.12

SL7 CONTAINERSHIP, FULL LOAD
30 KNOTS

HIGHEST LATERAL ACCELERATION @ (TOP OF CONTAINERS)
IN ONE YEAR (FT/S2)
(16-21 FT WAVE HEIGHT)

- HEADING -

LOCATION/ SPEED	0 DEG	30 DEG	60 DEG	90 DEG	120 DEG	150 DEG	180 DEG
G045S2:							
0 KNOTS	1.76	2.84	4.41	5.12	4.66	3.25	2.13
10 KNOTS	1.75	2.83	4.28	5.12	4.67	3.26	2.15
20 KNOTS	1.73	2.82	4.40	5.12	4.68	3.27	2.16
25 KNOTS	1.72	2.82	4.40	5.13	4.68	3.28	2.16
30 KNOTS	1.71	2.82	4.40	5.13	4.69	3.28	2.17
G128S9:							
0 KNOTS	1.57	2.57	4.01	4.67	4.25	2.97	1.98
10 KNOTS	1.56	2.57	4.01	4.67	4.67	2.98	1.99
20 KNOTS	1.55	2.56	4.01	4.67	4.26	2.99	2.00
25 KNOTS	1.54	2.56	4.01	4.67	4.27	2.99	2.00
30 KNOTS	1.53	2.56	4.01	4.68	4.27	3.00	2.01

TABLE B.13

SL7 CONTAINERSHIP, FULL LOAD
30 KNOTS

HIGHEST EXPECTED WAVE INDUCED VERTICAL BENDING MOMENT IN ONE YEAR (FT-L.TONS)
(16-21 FT WAVE HEIGHT)

- HEADING -

LOCATION/ SPEED	0 DEG	30 DEG	60 DEG	90 DEG	120 DEG	150 DEG	180 DEG
G045S2:							
0 KNOTS	548300	539520	521710	534200	640230	787400	852700
10 KNOTS	541700	533600	522020	534400	644900	794700	860900
20 KNOTS	533000	525940	513900	535420	649040	800700	867530
25 KNOTS	527610	521500	512240	536230	651000	803340	870410
30 KNOTS	522120	516940	511100	537200	652800	805800	873100
G128S9:							
0 KNOTS	493430	485940	471140	480600	568000	697900	756600
10 KNOTS	488430	481400	467840	480700	571600	703540	763000
20 KNOTS	481800	475130	464600	481600	574900	708200	768200
25 KNOTS	477400	471500	463300	482230	576400	710230	770500
30 KNOTS	4729100	467800	462320	483000	577800	712130	772510

TABLE B.14

SL7 CONTAINERSHIP, FULL LOAD
30 KNOTS, EQUAL PROBABILITY OF HEADING

HIGHEST VERTICAL SHEAR FORCE Ø (L.TONS) IN ONE YEAR

(16-21 FT WAVE HEIGHT)

- HEADING -

LOCATION/ SPEED	0 DEG	30 DEG	60 DEG	90 DEG	120 DEG	150 DEG	180 DEG
G045S2:							
0 KNOTS	2193.0	2169.2	2133.2	2119.0	2407.0	2881.1	3084.0
10 KNOTS	2162.0	2140.0	2120.0	2114.0	2423.1	2909.1	3116.0
20 KNOTS	2116.0	2099.1	2087.2	2114.1	2328.4	2932.1	3141.0
25 KNOTS	2090.0	2076.1	2078.0	2116.4	2446.0	2942.1	3152.1
30 KNOTS	2076.0	2061.1	2073.2	2120.0	2453.0	2951.4	3162.4
G128S9:							
0 KNOTS	2025.0	2007.4	1979.0	1951.4	2166.4	2563.0	2738.0
10 KNOTS	1998.0	1982.4	1960.0	1947.1	2180.0	2585.2	2763.0
20 KNOTS	1960.0	1948.4	1940.3	1947.3	2192.0	2603.3	2783.0
25 KNOTS	1938.0	1929.1	1932.4	1949.1	2198.3	2611.3	2791.2
30 KNOTS	1927.0	1917.0	1928.3	1952.0	2204.0	2619.0	2799.3

TABLE B.15

SL7 CONTAINERSHIP, FULL LOAD
30 KNOTS, EQUAL PROBABILITY OF HEADING

HIGHEST VERTICAL ACCELERATION @
BOW IN ONE YEAR (FT/S2)
(16-21 FT WAVE HEIGHT)

- HEADING -

LOCATION/ SPEED	0 DEG	30 DEG	60 DEG	90 DEG	120 DEG	150 DEG	180 DEG
G045S2:							
0 KNOTS	2.44	5.91	16.12	28.06	36.59	40.49	41.41
10 KNOTS	2.44	5.92	15.71	28.21	36.83	40.80	41.75
20 KNOTS	2.44	5.93	16.24	28.34	37.03	41.07	42.04
25 KNOTS	2.44	5.94	16.27	28.41	37.13	41.19	42.17
30 KNOTS	2.44	5.95	16.29	28.47	37.22	41.31	42.29
G128S9:							
0 KNOTS	2.33	7.03	14.66	25.01	32.18	35.76	36.90
10 KNOTS	2.33	7.04	14.71	25.13	32.37	36.00	37.18
20 KNOTS	2.33	7.06	14.76	25.24	32.53	36.21	37.41
25 KNOTS	2.33	7.07	14.78	25.30	32.61	36.30	37.51
30 KNOTS	2.33	7.08	14.80	25.34	32.68	36.39	37.60

TABLE B.16

VLCC FULL LOAD
16 KNOTS, EQUAL PROBABILITY OF HEADING

HIGHEST RESPONSE IN 20-YEAR PERIOD

LOCATION	VERTICAL BENDING MOMENT @ FT-L.TONS	VERTICAL SHEAR FORCE @ L. TONS	VERTICAL ACCEL. @ BOW FT/S2	LATERAL ACCEL. @ BRIDGE FT/S2
G037S9.SF	3095000	6074.3	30.02	12.68
G045S2.SF	3533000	7569.0	34.06	13.83
G056S3.SF	3394000	7203.0	32.31	13.02
G102S3.SF	3385000	7164.0	32.42	13.17
G105S9.SF	3343000	7195.1	32.21	13.40
G114S2.SF	3564000	7571.2	34.29	13.67
G124S9.SF	3461000	7398.2	33.41	13.41
G128S9.SF	3648000	7585.1	34.56	13.61
G181S9.SF	3330400	7237.1	32.29	13.49
G184S9.SF	3344300	7165.1	32.23	13.27
G187S9.SF	3548400	7537.0	34.07	13.66
G216S3.SF	3330100	7141.3	32.09	13.21
G272S7.SF	3097000	6771.0	30.22	12.85
G275S7.SF	3418000	7370.1	33.03	13.63
G278S7.SF	3577200	7752.0	34.75	14.17

TABLE B.17

VLCC FULL LOAD
16 KNOTS, EQUAL PROBABILITY OF HEADING

HIGHEST ROLL DISPLACEMENT (DEGREES) IN ONE YEAR

	- WAVE HEIGHT -									
LOCATION	0-3	3-6	6-9	9-12	12-16	16-21	21-27	27-32	32-40	40-50
G037S9	1.94	3.83	6.34	7.89	8.96	14.50	19.36	24.99	27.73	30.69
G045S2	1.81	3.59	5.68	8.05	10.28	14.89	18.96	23.98	29.19	32.37
G056S3	1.47	3.96	6.49	8.03	10.84	14.75	18.47	23.79	27.93	31.44
G102S3	1.77	3.55	6.10	8.23	11.24	14.97	19.82	23.15	26.84	30.66
G105S9	1.63	4.01	5.90	7.50	11.32	14.60	19.65	24.57	27.79	32.22
G114S2	1.84	4.19	6.54	7.76	10.80	14.19	19.31	23.93	28.49	32.16
G124S9	1.31	3.70	5.29	6.66	9.78	15.14	19.68	24.33	28.98	33.92
G128S9	1.86	4.09	5.85	8.34	10.09	13.44	19.80	21.90	27.49	31.16
G181S9	1.91	4.03	5.91	7.69	10.78	13.84	19.19	22.60	25.76	31.95
G184S9	1.97	3.64	6.23	8.15	9.94	14.12	18.55	22.88	27.85	31.08
G187S9	1.58	3.56	6.27	7.49	10.94	15.33	20.21	23.12	28.70	31.64
G216S3	1.97	4.61	6.23	8.08	10.98	13.05	19.13	23.32	27.34	30.35
G272S7	1.60	3.19	5.69	8.85	9.60	14.87	19.40	22.87	26.60	30.58
G275S7	1.66	3.44	5.61	7.46	11.92	14.12	19.76	23.28	27.98	32.24
G278S7	1.86	3.23	6.05	7.06	10.40	14.27	18.92	24.41	29.06	33.12

NOTE: indicates improbable operating condition.

TABLE B.18

VLCC FULL LOAD
16 KNOTS, EQUAL PROBABILITY OF HEADING

HIGHEST EXPECTED WAVE INDUCED VERTICAL BENDING MOMENT
IN ONE YEAR (FT-L.TONS)

	- WAVE HEIGHT -									
OCATION	0-3	3-6	6-9	9-12	12-16	16-21	21-27	27-32	32-40	40-50
037S9	162600	316500	545910	687800	795700	1195000	1595300	2103000	2404200	2784300
045S2	147830	291400	473400	672600	868320	1210000	1599100	1992000	2544000	2909200
056S3	122800	320000	526510	665400	919320	1233000	1569300	2017200	2432000	2836000
G102S3	139500	291500	514300	694940	954400	1288300	1676000	1961000	2353000	2776000
105S9	132900	328400	483700	617940	942200	1203100	1626000	2068100	2408300	2928000
114S2	148300	339040	542010	664200	903120	1204000	1612000	2019000	2468400	2882000
G124S9	112800	311800	436400	556300	782330	1251000	1642000	2092000	2517000	3083000
128S9	146320	330320	472000	697100	849000	1126000	1679000	1857000	2412200	2850000
181S9	157600	347000	504420	661720	906100	1184000	1638400	1928000	2285000	2814300
G184S9	160930	304400	513700	688800	849900	1193400	1578000	1949000	2460300	2800300
187S9	125300	284300	506800	629700	824800	1284000	1702000	1943000	2515000	2865000
216S3	161700	375940	530300	690820	934800	1105300	1620000	2001000	2414000	2728300
272S7	134310	265600	474300	725900	804740	1256400	1606000	1946000	2357000	2756200
G275S7	132700	277300	460010	627720	974300	1138300	1656400	1956000	2466000	2909000
278S7	147030	264300	499600	584400	886000	1181000	1581000	2056300	2534000	2985100

NOTE: indicates improbable operating condition.

TABLE B.19

VLCC FULL LOAD
16 KNOTS, EQUAL PROBABILITY OF HEADING

HIGHEST VERTICAL SHEAR FORCE [illegible] IN ONE YEAR (L.TONS)

LOCATION	- WAVE HEIGHT - 0-3	3-6	6-9	9-12	12-16	16-21	21-27	27-32	32-40	40-50
G037S9	497.5	925.5	1237.3	1736.2	2473.0	3424.4	4050.1	5049.0	5514.0	6033.0
G045S2	544.7	829.7	1341.0	1909.0	2495.0	3375.1	3920.3	4911.3	5797.3	6360.0
G056S3	429.7	985.9	1320.0	1732.0	2390.0	3168.0	3804.0	4804.1	5536.0	6171.4
G102S3	534.9	903.3	1225.0	1759.0	2403.1	3099.0	4036.0	4707.0	5320.2	6035.3
G105S9	481.0	927.2	1395.0	1780.0	2528.0	3326.0	4054.2	4959.0	5511.0	6301.4
G114S2	466.8	937.9	1363.0	1821.0	2569.0	3161.0	4057.4	4848.0	5667.3	6336.0
G124S9	296.4	808.3	1448.1	1843.0	2616.0	3215.3	4040.0	4874.0	5748.3	6617.4
G128S9	485.8	952.4	1450.4	1800.2	2290.0	3080.2	4068.0	4458.2	5455.0	6119.1
G181S9	462.8	803.1	1332.0	1791.0	2473.0	2934.3	3901.0	4566.2	5093.1	6299.2
G184S9	530.6	848.2	1361.0	1759.0	2488.4	3088.4	3849.3	4626.3	5525.0	6113.1
G187S9	499.3	912.4	1504.0	1828.3	2263.2	3275.1	4139.1	4701.0	5681.0	6209.1
G216S3	545.0	1006.0	1374.0	1901.0	2390.0	3091.0	3908.1	4686.0	5430.0	5978.0
G272S7	350.2	820.8	1256.2	1856.2	2592.0	3372.0	4136.4	4641.0	5263.0	6019.4
G275S7	490.3	912.4	1305.0	1663.0	2617.0	3274.0	4074.0	4076.3	5563.0	6327.3
G278S7	562.6	921.8	1290.3	1803.2	2395.0	3181.1	3948.3	4958.2	5781.0	6513.0

NOTE: indicates improbable operating condition.

TABLE B.20

VLCC FULL LOAD
16 KNOTS, EQUAL PROBABILITY OF HEADING

HIGHEST VERTICAL ACCELERATION @ BOW IN ONE YEAR (FT/S2)

LOCATION	0-3	3-6	6-9	9-12	12-16	16-21	21-27	27-32	32-40	40-50
	- WAVE HEIGHT -									
G037S9	1.62	3.22	5.66	7.05	7.82	12.32	16.50	21.61	24.16	27.08
G045S2	1.47	3.07	4.93	7.03	8.96	12.61	16.39	20.70	25.52	28.48
G056S3	1.24	3.24	5.49	6.95	9.58	12.69	15.99	20.63	24.35	27.68
G102S3	1.48	3.07	5.37	7.19	9.83	13.15	17.17	20.06	23.44	27.03
G105S9	1.37	3.38	5.06	6.44	9.77	12.47	16.89	21.17	24.21	28.33
G114S2	1.56	3.58	5.71	6.88	9.34	12.39	16.63	20.73	24.79	28.26
G124S9	1.09	3.19	4.50	5.76	8.24	13.08	16.90	21.14	25.26	29.90
G128S9	1.55	3.41	4.97	7.21	8.82	11.51	17.12	18.91	24.01	27.48
G181S9	1.59	3.48	5.16	6.87	9.40	11.99	16.62	19.59	22.56	27.97
G184S9	1.65	3.18	5.38	7.12	8.77	12.24	16.02	19.84	24.40	27.39
G187S9	1.32	3.01	5.35	6.58	9.49	13.26	17.42	19.96	25.10	27.91
G216S3	1.64	3.94	5.42	7.05	9.54	11.22	16.54	20.25	23.95	26.70
G272S7	1.37	2.76	4.96	7.65	8.33	12.84	16.58	19.79	23.22	26.94
G275S7	1.36	2.97	4.86	6.52	10.26	11.90	17.07	20.14	24.51	28.39
G278S7	1.54	2.84	5.20	6.02	9.14	12.13	16.28	21.15	25.38	29.17

NOTE: indicates improbable operating condition.

TABLE B.21

VLCC FULL LOAD
16 KNOTS, EQUAL PROBABILITY OF HEADING

HIGHEST LATERAL ACCELERATION @ BRIDGE IN ONE YEAR (FT/S2)

	- WAVE HEIGHT -									
LOCATION	0-3	3-6	6-9	9-12	12-16	16-21	21-27	27-32	32-40	40-50
G037S9	1.10	2.20	2.54	3.95	5.75	8.11	9.46	10.76	10.94	11.24
G045S2	1.20	1.89	3.10	4.41	5.75	8.01	9.03	10.95	11.39	11.86
G056S3	.99	2.31	3.07	3.97	5.51	7.44	8.73	10.26	10.84	11.46
G102S3	1.22	2.09	2.66	4.05	5.51	7.10	9.03	10.18	10.53	11.43
G105S9	1.04	2.13	3.26	4.14	5.90	7.91	9.28	10.72	10.80	11.82
G114S2	1.08	2.18	3.12	4.15	5.98	7.38	9.49	10.46	11.41	11.98
G124S9	.69	1.88	3.29	4.17	6.09	7.47	9.12	10.15	11.27	12.08
G128S9	1.13	2.25	3.35	4.15	5.28	7.28	9.28	9.84	10.85	11.41
G181S9	1.06	1.53	3.06	4.17	5.78	6.84	8.66	9.90	10.09	11.91
G184S9	1.22	1.98	3.15	4.06	5.68	7.23	8.89	9.92	10.94	11.47
G187S9	1.16	2.11	3.52	4.20	5.19	7.65	9.36	10.30	11.03	11.51
G216S3	1.24	2.35	3.14	4.39	5.54	7.29	8.77	9.83	10.78	11.31
G272S7	.81	1.86	2.96	4.28	5.85	7.98	9.83	10.13	10.59	11.46
G275S7	1.08	2.17	3.02	3.81	6.08	7.78	9.34	10.27	11.03	11.81
G278S7	1.25	2.13	2.95	4.11	5.52	7.47	9.19	10.79	11.43	12.14

NOTE: indicates improbable operating condition.

TABLE B.22

87,000 DWT TANKER
16.5 KNOTS, EQUAL PROBABILITY OF HEADING

HIGHEST RESPONSE IN 20-YEAR PERIOD

LOCATION	VERTICAL BENDING MOMENT Ø FT-L.TONS	VERTICAL SHEAR FORCE Ø L. TONS	VERTICAL ACCEL. @ BOW FT/S2	LATERAL ACCEL. @ BRIDGE FT/S2
G037S9	1913000	4879.0	33.70	12.26
G045S2	2171300	5462.0	38.08	13.33
G056S3	2076200	5170.2	36.28	12.52
G102S3	2068100	5152.2	36.15	12.67
G105S9	2063300	5198.0	36.12	12.96
G114S2	2182000	5436.0	38.22	13.13
G124S9	2123300	5326.0	37.33	12.89
G128S9	2211000	5392.2	38.31	13.17
G181S9	2056300	5299.3	36.34	12.96
G184S9	2057000	5177.0	36.05	12.84
G187S9	2173100	5405.0	37.96	13.30
G216S3	2049300	5161.1	35.90	12.80
G272S7	1924000	4949.3	34.07	12.47
G275S7	2109000	5336.0	37.03	13.23
G278S7	2211100	5620.0	39.00	13.55

TABLE B.23

87,000 DWT TANKER
16.5 KNOTS, EQUAL PROBABILITY OF HEADING

HIGHEST ROLL DISPLACEMENT IN ONE YEAR (DEGREES)

- WAVE HEIGHT -

LOCATION	0-3	3-6	6-9	9-12	12-16	16-21	21-27	27-32	32-40	40-50
G037S9	2.30	4.73	6.50	8.25	10.95	17.31	22.07	26.93	28.73	30.85
G045S2	2.28	4.29	6.53	9.34	11.90	17.72	21.21	26.62	30.10	32.47
G056S3	1.85	4.85	7.36	9.08	12.07	16.87	20.56	25.60	28.68	31.53
G102S3	2.43	4.38	6.50	9.03	12.36	16.29	21.71	25.23	27.61	30.96
G105S9	2.05	4.78	6.88	8.87	12.38	17.27	22.09	26.73	28.62	32.37
G114S2	2.22	4.96	7.20	8.52	12.53	16.18	21.88	25.95	29.64	32.51
G124S9	1.48	4.35	6.38	7.93	12.43	17.23	21.90	25.75	29.85	33.55
G128S9	2.36	5.03	7.10	9.33	11.39	15.78	21.94	23.98	28.40	31.27
G181S9	2.26	4.36	6.52	8.61	12.38	15.57	21.00	24.44	26.47	32.43
G184S9	2.39	4.16	7.10	9.03	11.27	16.04	20.78	24.71	28.72	31.32
G187S9	2.14	4.37	7.77	8.53	11.99	17.36	22.44	25.28	29.36	31.65
G211S3	2.46	5.35	6.91	9.00	12.23	15.32	20.98	24.80	28.27	30.69
G272S7	1.83	3.92	6.39	9.25	11.42	17.30	22.50	24.95	27.68	30.98
G275S7	2.13	4.40	6.93	8.25	13.70	17.06	22.04	28.91	32.29	32.29
G278S7	2.42	4.17	6.73	8.38	11.66	16.66	21.44	26.66	30.04	33.25

NOTE: indicates improbable operating condition.

AD-A160 158 EFFECT OF VARIOUS WAVE CONDITIONS ON DYNAMIC HULL GIRDER LOADINGS(U) HOFFMAN MARITIME CONSULTANTS INC GLEN HEAD NY JUN 84 HMC-R83267 USCG-M-84-3(16718) 2/2

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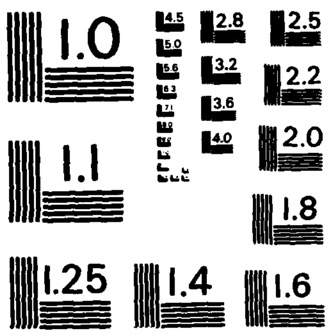

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TABLE B.24

87,000 DWT TANKER
16.5 KNOTS, EQUAL PROBABILITY OF HEADING

HIGHEST VERTICAL BENDING MOMENT IN ONE YEAR (FT.L. TONS)

- WAVE HEIGHT -

LOCATION	0-3	3-6	6-9	9-12	12-16	16-21	21-27	27-32	32-40	40-50
G037S9	111900	228900	343500	430410	522440	827200	1077000	1377000	1532000	1722000
G045S2	109630	208400	320200	454800	581940	849000	1055000	1323400	1613000	1805100
G056S3	88860	232900	360710	448300	602400	828500	1029000	1312400	1541400	1757000
G102S3	117610	215210	332500	453900	621800	829520	1097400	1284000	1487000	1719000
G105S9	99011	229040	334900	431640	636610	829640	1089000	1356000	1531100	1807200
G114S2	106800	243400	358700	429300	609910	797130	1076000	1321000	1572000	1794000
G124S9	74970	216600	308700	383400	589000	844420	1094000	1346000	1598400	1895000
G128S9	112500	240400	341200	464800	564130	763700	1102000	1216000	1525400	1746200
G181S9	109100	227030	328120	428310	605800	776600	1068000	1256000	1434000	1769200
G184S9	114000	205600	349500	452600	554940	791900	1036400	1267000	1549300	1738000
G187S9	101930	208600	378000	419300	605200	857200	1125000	1278000	1587000	1772000
G211S3	118600	259200	347900	449930	614100	740800	1062300	1291000	1522000	1697000
G272S7	91083	189900	317600	489320	552120	839000	1085300	1269000	1482300	1711300
G275S7	102700	208800	338200	414210	666900	813230	1098000	1286300	1556000	1802000
G278S7	115400	198400	333700	406040	579610	812010	1055400	1349000	1608000	1851000

NOTE: indicates improbable operating condition.

TABLE B.25

87,000 DWT TANKER
16.5 KNOTS, EQUAL PROBABILITY OF HEADING

HIGHEST VERTICAL SHEAR FORCE IN ONE YEAR (L.TONS)

LOCATION	0-3	3-6	6-9	9-12	12-16	16-21	21-27	27-32	32-40	40-50
	- WAVE HEIGHT -									
G037S9	463.9	880.3	1100.0	1783.0	2309.3	3043.0	3291.0	3888.4	4119.0	4375.0
G045S2	526.8	734.4	1284.2	1776.4	2306.0	2903.0	3172.1	3857.2	4319.4	4633.0
G056S3	437.5	893.9	1165.0	1564.0	2183.0	2689.3	3072.0	3691.0	4117.3	4484.0
G102S3	474.9	857.6	1157.0	1655.0	2176.0	2648.3	3202.0	3635.0	3953.0	4398.0
G105S9	458.5	880.3	1346.0	1641.0	2260.1	7883.0	3239.3	3822.3	4103.0	4556.1
G114S2	460.0	855.8	1289.0	1804.1	2412.0	2763.0	3344.4	3745.3	4257.0	4638.0
G124S9	270.1	721.7	1402.0	1805.0	2362.1	2712.4	3209.0	3694.3	4283.3	4774.0
G128S9	466.8	829.2	1335.0	1655.0	2125.0	2693.0	3280.4	3481.0	4057.3	4442.0
G181S9	424.4	639.9	1322.3	1699.0	2272.1	2488.0	3056.0	3527.0	3769.2	4644.0
G184S9	515.6	824.7	1231.0	1648.0	2428.0	2695.0	3137.1	3558.0	4099.3	4456.0
G187S9	489.6	879.5	1338.0	1769.1	2047.4	2784.1	3284.0	3653.3	4212.0	4500.3
G216S3	505.3	915.3	1339.0	1864.4	2171.0	2802.0	3118.0	3568.0	4040.0	4366.0
G272S7	330.8	800.7	1242.2	1667.0	2497.0	2951.0	3414.3	3598.0	3922.0	4395.2
G275S7	461.7	841.1	1222.0	1605.3	2326.3	2812.0	3286.2	3667.1	4140.0	4597.0
G278S7	537.4	912.5	1221.0	1745.1	2241.2	2747.0	3216.0	3844.0	4313.0	4742.0

NOTE: indicates improbable operating condition.

TABLE B.26

87,000 DWT TANKER
16.5 KNOTS, EQUAL PROBABILITY OF HEADING

HIGHEST VERTICAL ACCELERATION @ BOW IN ONE YEAR (FT/S2)

LOCATION	0-3	3-6	6-9	9-12	12-16	16-21	21-27	27-32	32-40	40-50
G037S9	1.88	3.75	6.51	8.10	8.90	14.54	19.46	25.10	27.62	30.38
G045S2	1.71	3.57	5.73	8.19	10.40	14.93	19.11	24.31	29.11	32.04
G056S3	1.43	3.83	6.49	8.15	11.11	14.85	18.59	23.91	27.76	31.08
G102S3	1.71	3.54	6.23	8.35	11.41	15.17	19.97	23.32	26.67	30.38
G105S9	1.58	3.96	5.93	7.55	11.44	14.70	19.84	24.64	27.65	31.75
G114S2	1.83	4.16	6.67	7.91	10.92	14.33	19.46	24.10	28.38	31.87
G124S9	1.27	3.69	5.25	6.75	9.80	15.37	19.74	24.29	28.84	33.42
G128S9	1.85	4.03	5.84	8.41	10.27	13.46	19.89	21.97	27.32	30.82
G181S9	1.88	4.03	5.91	7.93	10.97	13.88	19.24	22.61	25.56	31.70
G184S9	1.95	3.72	6.28	8.28	10.16	14.24	18.60	22.99	27.71	30.81
G187S9	1.56	3.56	6.22	7.65	11.05	15.46	20.28	23.25	28.53	31.29
G216S3	1.91	4.63	6.22	8.10	11.00	13.06	19.17	23.33	27.23	30.08
G272S7	1.61	3.18	5.75	8.94	9.74	14.95	19.59	22.93	26.43	30.33
G275S7	1.59	3.49	5.66	7.59	12.12	14.16	19.93	23.47	27.88	31.87
G278S7	1.80	3.29	6.07	7.07	10.65	14.25	19.07	24.63	28.97	32.79

NOTE: indicates improbable operating condition.

TABLE B.27

87,000 DWT TANKER
16.5 KNOTS, EQUAL PROBABILITY OF HEADING

HIGHEST LATERAL ACCELERATION @ BRIDGE IN ONE YEAR (FT/S^2)

	- WAVE HEIGHT -									
LOCATION	0-3	3-6	6-9	9-12	12-16	16-21	21-27	27-32	32-40	40-50
G037S9	1.23	2.47	2.94	4.80	6.55	8.77	9.56	10.57	10.60	10.87
G045S2	1.39	2.07	3.57	4.99	6.51	8.46	9.22	10.77	10.96	11.41
G056S3	1.20	2.57	3.29	4.36	6.15	7.82	8.95	10.11	10.49	11.05
G102S3	1.37	2.39	3.09	4.59	6.13	7.63	9.19	10.05	10.34	11.10
G105S9	1.20	2.43	3.75	4.60	6.45	8.42	9.32	10.53	10.38	11.46
G114S2	1.26	2.39	3.55	4.94	6.80	7.96	9.77	10.32	11.06	11.54
G124S9	.75	2.04	3.88	4.98	6.75	7.83	9.22	10.04	10.85	11.63
G128S9	1.29	2.41	3.78	4.61	5.96	7.83	9.51	9.86	10.61	11.05
G181S9	1.16	1.70	3.65	4.75	6.43	7.21	8.75	9.91	9.88	11.41
G184S9	1.38	2.27	3.48	4.56	6.72	7.76	9.15	9.81	10.69	11.06
G187S9	1.37	2.44	3.84	4.92	5.70	8.07	9.49	10.20	10.64	11.12
G216S3	1.42	2.61	3.68	5.17	6.15	8.01	8.97	9.73	10.53	10.95
G272S7	.91	2.20	3.43	4.70	6.95	8.60	10.08	10.06	10.37	11.13
G275S7	1.24	2.40	3.38	4.39	6.60	8.23	9.54	10.13	10.72	11.47
G278S7	1.44	2.51	3.37	4.80	6.27	7.95	9.40	10.64	11.06	11.69

NOTE: indicates improbable operating condition.

TABLE B.28

GENERAL CARGO SHIP
16 KNOTS, EQUAL PROBABILITY OF HEADING

HIGHEST RESPONSE IN 20 YEAR PERIOD

LOCATION	VERTICAL BENDING MOMENT Ø FT-L.TONS	VERTICAL SHEAR FORCE Ø L. TONS	VERTICAL ACCEL. @ BOW FT/S2	LATERAL ACCEL. @ BRIDGE FT/S2
G037S9	195330	1042.0	68.06	15.41
G045S2	213700	1112.1	73.03	17.45
G056S3	199630	1042.2	68.83	16.37
G102S3	201700	1055.0	69.43	16.43
G105S9	204400	1089.0	71.99	16.53
G114S2	209600	1096.2	72.25	17.20
G124S9	206900	1072.0	70.29	16.94
G128S9	207730	1079.3	71.39	17.24
G181S9	205600	1091.0	72.75	16.52
G184S9	203900	1069.3	70.30	16.51
G187S9	212140	1100.0	71.78	17.48
G216S3	203100	1062.0	69.80	16.44
G272S7	197300	1045.0	68.44	15.78
G275S7	211540	1100.2	71.83	17.17
G278S7	216000	1125.0	74.57	17.61

TABLE B.29

GENERAL CARGO SHIP
16 KNOTS, EQUAL PROBABILITY OF HEADING

HIGHEST ROLL DISPLACEMENT IN ONE YEAR (DEGREE)

	- WAVE HEIGHT -									
LOCATION	0-3	3-6	6-9	9-12	12-16	16-21	21-27	27-32	32-40	40-50
G037S9	3.95	7.53	8.97	14.01	19.17	26.97	31.58	37.31	39.70	43.79
G045S2	4.36	6.57	10.67	15.07	19.79	26.81	30.48	36.81	41.34	45.54
G056S3	3.55	7.76	10.21	13.75	19.08	25.08	29.63	35.48	39.66	44.55
G102S3	4.08	7.21	9.51	13.99	19.09	24.19	30.88	35.20	38.49	43.80
G105S9	3.89	7.34	10.99	14.44	20.16	26.41	31.24	36.93	39.24	46.01
G114S2	3.77	7.44	10.78	14.61	20.37	25.16	31.79	36.02	40.96	45.60
G124S9	2.36	6.38	8.00	14.67	20.73	25.41	31.36	36.06	41.07	47.65
G128S9	3.85	7.36	11.42	14.40	18.33	24.44	31.60	34.01	39.71	44.42
G181S9	3.66	5.10	10.55	14.28	19.68	23.31	29.85	34.52	37.11	44.98
G184S9	4.27	6.96	10.81	14.15	19.64	24.60	30.25	34.48	40.12	44.11
G187S9	3.96	7.10	11.90	14.57	17.97	25.98	31.99	35.32	40.64	44.92
G216S3	4.38	7.73	10.75	15.04	19.03	24.64	30.30	34.72	39.54	43.24
G272S7	2.76	6.23	10.11	14.61	20.28	26.59	32.47	35.09	38.71	43.71
G275S7	3.87	7.18	10.25	13.47	20.85	26.04	31.63	35.36	40.32	45.81
G278S7	4.46	7.18	10.23	14.42	19.06	25.57	30.93	36.92	41.50	46.93

NOTE: indicates improbable operating condition.

TABLE B.30

GENERAL CARGO SHIP
16 KNOTS, EQUAL PROBABILITY OF HEADING

HIGHEST EXPECTED WAVE INDUCED VERTICAL BENDING MOMENT
IN ONE YEAR (FT-L.TONS)

	- WAVE HEIGHT -									
LOCATION	0-3	3-6	6-9	9-12	12-16	16-21	21-27	27-32	32-40	40-50
G037S9	21020	41060	52460	83670	106710	139830	150000	167140	168200	171500
G045S2	23930	33700	59700	82040	106240	134230	145140	168420	173700	181300
G056S3	21041	42312	55110	72490	101100	124800	140740	159500	167000	175500
G102S3	22030	40734	54090	77540	100510	121720	145300	158610	164200	175400
G105S9	20010	40720	64300	76910	104500	133240	146200	164100	164930	180120
G114S2	21690	40410	60610	84394	111840	127500	153800	162500	175410	183100
G124S9	13060	35180	47191	84050	109400	125010	145920	159340	172230	186100
G128S9	21764	39050	61244	77144	98683	124210	150500	156300	168400	175310
G181S9	19780	29704	62400	78873	105500	115120	137840	156420	156220	180400
G184S9	24051	39270	57790	76920	112110	124510	144400	155000	169210	175100
G187S9	23670	41961	62860	82620	95510	128600	149100	161030	169500	176700
G216S3	23982	42990	62420	86663	101000	130000	142800	154810	166800	173530
G272S7	16110	37210	61230	78150	114310	135700	156040	157700	161630	176100
G275S7	21050	40601	57590	75000	107430	129700	150230	160110	170300	182800
G278S7	24590	43920	56803	81363	103600	127430	147300	166500	175700	186040

NOTE: indicates improbable operating condition.

TABLE B.31

GENERAL CARGO SHIP
16 KNOTS, EQUAL PROBABILITY OF HEADING

HIGHEST VERTICAL SHEAR FORCE IN ONE YEAR (L.TONS)

	- WAVE HEIGHT -									
LOCATION	0-3	3-6	6-9	9-12	12-16	16-21	21-27	27-32	32-40	40-50
G037S9	150.9	305.9	501.8	658.3	638.0	798.9	830.7	903.0	894.7	905.7
G045S2	212.3	318.2	461.2	574.8	670.5	750.9	799.7	917.1	923.6	952.3
G056S3	185.9	316.0	469.5	511.9	633.7	693.6	775.0	862.9	884.4	920.3
G102S3	169.7	315.8	480.3	561.3	634.6	706.8	798.6	857.9	879.2	923.3
G105S9	170.3	388.7	509.1	556.0	646.6	748.4	803.2	901.0	877.6	958.5
G114S2	194.7	351.6	534.3	610.3	738.8	724.5	850.2	879.3	935.6	963.7
G124S9	164.7	334.4	495.1	563.2	644.5	705.6	796.9	856.3	913.4	966.0
G128S9	188.7	294.7	414.4	571.2	638.3	701.1	826.3	846.6	898.5	919.9
G181S9	146.9	352.2	458.5	547.9	657.9	658.1	758.0	853.8	835.2	961.2
G184S9	193.1	327.7	447.0	563.3	757.9	704.3	796.6	836.3	903.7	917.8
G187S9	167.3	301.4	414.0	581.1	673.6	722.3	821.5	873.8	896.7	923.6
G216S3	158.6	332.9	502.5	638.9	664.4	814.2	782.9	830.0	887.1	911.3
G272S7	149.1	346.2	489.2	562.1	735.3	775.0	829.1	862.7	879.9	923.1
G275S7	164.7	340.7	559.5	557.3	646.3	733.4	823.8	861.9	906.6	957.4
G278S7	175.5	365.8	490.1	603.4	657.7	714.3	813.6	905.3	936.0	973.0

NOTE: indicates improbable operating condition.

TABLE B.32

GENERAL CARGO SHIP
16 KNOTS, EQUAL PROBABILITY OF HEADING

HIGHEST VERTICAL ACCELERATION @ BOW IN ONE YEAR (FT/S2)

	- WAVE HEIGHT -									
LOCATION	0-3	3-6	6-9	9-12	12-16	16-21	21-27	27-32	32-40	40-50
G037S9	6.07	12.62	14.18	21.64	33.83	46.55	52.97	58.39	48.54	59.87
G045S2	6.40	11.71	17.79	25.79	33.35	45.36	50.03	59.25	60.65	62.79
G056S3	5.20	12.88	18.16	22.72	31.34	41.45	48.32	55.55	57.80	60.77
G102S3	7.37	11.92	15.43	22.69	31.80	40.65	49.72	55.12	56.77	60.60
G105S9	5.73	12.31	18.54	23.18	33.51	44.74	51.15	58.98	57.70	63.41
G114S2	6.18	12.39	17.72	23.26	33.99	42.37	52.90	56.62	61.03	63.59
G124S9	3.61	9.95	13.04	24.02	35.17	41.97	50.20	54.95	60.08	63.22
G128S9	6.37	13.26	20.01	23.26	29.77	41.53	51.26	53.71	58.33	60.47
G181S9	5.70	9.30	17.69	23.35	32.76	38.26	47.94	54.42	54.24	64.18
G184S9	6.10	10.64	18.31	22.40	32.81	40.83	49.50	53.68	58.70	60.54
G187S9	6.28	12.18	20.48	23.97	28.58	43.12	51.93	55.97	58.68	60.74
G216S3	6.78	14.08	18.57	24.74	31.00	40.94	48.51	53.05	57.70	59.91
G272S7	4.35	10.85	15.87	25.01	35.24	45.86	51.33	55.69	57.85	60.39
G275S7	6.03	12.03	17.96	21.11	34.73	44.29	51.44	55.37	58.98	62.33
G278S7	6.77	11.82	17.58	23.52	31.43	42.09	51.13	58.57	61.10	64.15

NOTE: indicates improbable operating condition.

TABLE B.33

GENERAL CARGO SHIP
16 KNOTS, EQUAL PROBABILITY OF HEADING

HIGHEST LATERAL ACCELERATION @ BRIDGE IN ONE YEAR (FT/S2)

	- WAVE HEIGHT -									
LOCATION	0-3	3-6	6-9	9-12	12-16	16-21	21-27	27-32	32-40	40-50
G037S9	1.54	2.93	3.95	5.98	7.27	9.72	10.87	12.55	13.13	13.92
G045S2	1.88	2.64	4.34	5.81	7.52	9.49	10.53	12.45	13.57	14.62
G056S3	1.61	3.06	4.06	5.20	7.20	8.98	10.26	11.95	13.08	14.25
G102S3	1.53	2.99	4.08	5.58	7.13	8.64	10.65	11.89	12.73	14.09
G105S9	1.58	3.21	4.59	5.63	7.46	9.42	10.68	12.29	12.89	14.63
G114S2	1.64	3.09	4.49	6.04	7.85	9.08	11.04	12.16	13.61	14.71
G124S9	1.80	2.78	3.73	5.94	7.73	9.01	10.76	12.12	13.49	15.27
G128S9	1.64	2.75	4.31	5.61	7.05	8.77	10.94	11.62	13.12	14.23
G181S9	1.46	2.36	4.37	5.66	7.44	8.35	10.22	11.72	12.20	14.46
G184S9	1.82	2.99	4.24	5.60	7.79	8.87	10.53	11.66	13.21	14.17
G187S9	1.65	2.92	4.28	5.89	6.92	9.22	10.95	11.98	13.34	14.40
G216S3	1.72	3.00	4.37	6.12	7.21	9.22	10.50	11.73	13.03	13.95
G272S7	1.26	2.74	4.39	5.57	7.83	9.49	11.14	11.80	12.69	14.16
G275S7	1.57	2.95	4.26	5.49	7.60	9.25	10.93	11.97	13.30	14.82
G278S7	1.78	3.16	4.22	5.86	7.33	9.17	10.67	12.41	13.68	15.08

NOTE: indicates improbable operating condition.

TABLE B.34

ISSC WAVE HEIGHTS AND PERIODS FOR GRID POINT 128

H-1/3 (FEET)	T (SEC)
2.144	6.721
4.662	6.810
7.426	7.195
10.542	7.794
13.710	8.521
18.055	9.449
24.215	10.520
28.443	11.418
35.343	12.480
45.221	13.936
53.802	14.944
62.141	16.017

TABLE B.35

SL-7 CONTAINERSHIP, FULL LOAD

HIGHEST EXPECTED WAVE INDUCED VERTICAL BENDING MOMENT @

IN 20 YEAR PERIOD (FT L.TONS)

	G128S9	STATION INDIA	ISSC FOR GP128
HINDCAST EXCEEDANCE	1403000	1574000	1402000
MEASURED EXCEEDANCE	1263100	1444000	1246400
OBSERVED EXCEEDANCE	1094200	1238000	1081400

HIGHEST VERTICAL SHEAR FORCE 0 IN 20 YEAR PERIOD (L.TONS)

	G128S9	STATION INDIA	ISSC OR GP128
HINDCAST EXCEEDANCE	4121.1	4779.0	4144.0
MEASURED EXCEEDANCE	3787.0	4392.2	3754.0
OBSERVED EXCEEDANCE	3477.0	3892.2	3374.0

HIGHEST VERTICAL ACCELERATION @ BOW IN 20 YEAR PERIOD (FT/S2)

	G128S9	STATION INDIA	ISSC FOR GP128
HINDCAST EXCEEDANCE	71.65	84.42	71.72
MEASURED EXCEEDANCE	64.86	77.4	63.94
OBSERVED EXCEEDANCE	56.39	66.4	55.58

HIGHEST LATERAL ACCELERATION @ TOP OF CONTAINERS IN 20 YEARS (FT/S2)

	G128S9	STATION INDIA	ISSC FOR GP128
HINDCAST EXCEEDANCE	8.15	8.65	8.15
MEASURED EXCEEDANCE	7.26	8.01	7.19
OBSERVED EXCEEDANCE	6.32	6.91	6.25

TABLE B.36

VLCC, FULL LOAD

HIGHEST EXPECTED WAVE INDUCED VERTICAL BENDING MOMENT @ IN 20 YEAR PERIOD (FT.L.TONS)

	G128S9	STATION INDIA	ISSC FOR GP128
HINDCAST EXCEEDANCE	2632100	2807100	2603000
MEASURED EXCEEDANCE	2325000	2578000	2273000
OBSERVED EXCEEDANCE	1965200	2187100	1936000

HIGHEST VERTICAL SHEAR FORCE @ IN 20 YEAR PERIOD (L.TONS)

	G128S9	STATION INDIA	ISSC OR GP128
HINDCAST EXCEEDANCE	5658.3	6414.1	5658.2
MEASURED EXCEEDANCE	5092.0	5881.0	5025.0
OBSERVED EXCEEDANCE	4409.0	5036.0	4355.0

HIGHEST VERTICAL ACCELERATION @ BOW IN 20 YEAR PERIOD (FT/S2)

	G128S9	STATION INDIA	ISSC FOR GP128
HINDCAST EXCEEDANCE	25.51	28.35	25.39
MEASURED EXCEEDANCE	22.80	26.05	22.37
OBSERVED EXCEEDANCE	19.47	22.25	19.22

HIGHEST LATERAL ACCELERATION @ TOP OF CONTAINERS IN 20 YEARS (FT/S2)

	G128S9	STATION INDIA	ISSC FOR GP128
HINDCAST EXCEEDANCE	10.81	12.40	10.90
MEASURED EXCEEDANCE	10.04	11.47	9.94
OBSERVED EXCEEDANCE	9.41	10.32	9.07

TABLE B.37

87,000 DWT TANKER

HIGHEST EXPECTED WAVE INDUCED VERTICAL BENDING MOMENT ℄ IN 20 YEAR PERIOD (FT.L.TONS)

	G128S9	STATION INDIA	ISSC FOR GP128
HINDCAST EXCEEDANCE	1621400	1778000	1614000
MEASURED EXCEEDANCE	1448000	1633300	1423200
OBSERVED EXCEEDANCE	1239000	1394100	1224400

HIGHEST VERTICAL SHEAR FORCE ℄ IN 20 YEAR PERIOD (L.TONS)

	G128S9	STATION INDIA	ISSC OR GP128
HINDCAST EXCEEDANCE	4119.0	4765.0	4131.0
MEASURED EXCEEDANCE	3748.0	4375.0	3707.0
OBSERVED EXCEEDANCE	3374.3	3820.0	3283.2

HIGHEST VERTICAL ACCELERATION @ BOW IN 20 YEAR PERIOD (FT/S2)

	G128S9	STATION INDIA	ISSC FOR GP128
HINDCAST EXCEEDANCE	28.57	32.26	28.59
MEASURED EXCEEDANCE	25.66	29.62	25.28
OBSERVED EXCEEDANCE	22.07	25.39	21.82

HIGHEST LATERAL ACCELERATION @ TOP OF CONTAINERS IN 20 YEARS (FT/S2)

	G128S9	STATION INDIA	ISSC FOR GP128
HINDCAST EXCEEDANCE	10.58	11.90	10.63
MEASURED EXCEEDANCE	9.94	11.10	9.76
OBSERVED EXCEEDANCE	9.50	10.37	9.06

TABLE B.38

GENERAL CARGO SHIP

HIGHEST EXPECTED WAVE INDUCED VERTICAL BENDING MOMENT Ø IN 20 YEAR PERIOD (FT.L.TONS)

	G128S9	STATION INDIA	ISSC FOR GP128
HINDCAST EXCEEDANCE	167600	190310	167600
MEASURED EXCEEDANCE	157400	176700	154300
OBSERVED EXCEEDANCE	150440	162920	143720

HIGHEST VERTICAL SHEAR FORCE Ø IN 20 YEAR PERIOD (L.TONS)

	G12859	STATION INDIA	ISSC OR GP128
HINDCAST EXCEEDANCE	893.6	1097.0	886.8
MEASURED EXCEEDANCE	847.2	1017.0	821.9
OBSERVED EXCEEDANCE	818.3	936.1	774.3

HIGHEST VERTICAL ACCELERATION @ BOW IN 20 YEAR PERIOD (FT/S2)

	G128S9	STATION INDIA	ISSC FOR GP128
HINDCAST EXCEEDANCE	57.77	64.65	57.91
MEASURED EXCEEDANCE	54.08	66.12	53.16
OBSERVED EXCEEDANCE	51.41	56.24	49.14

HIGHEST LATERAL ACCELERATION @ TOP OF CONTAINERS IN 20 YEARS (FT/S2)

	G128S9	STATION INDIA	ISSC FOR GP128
HINDCAST EXCEEDANCE	13.35	15.29	13.36
MEASURED EXCEEDANCE	12.24	14.18	12.10
OBSERVED EXCEEDANCE	11.23	12.51	10.93

TABLE B.39

HIGHEST EXPECTED WAVE INDUCED VERTICAL BENDING MOMENT IN 20 YEAR PERIOD (FT.L.TONS)

SL-7 CONTAINERSHIP

	HINDCAST SPECTRA GP128	STATION INDIA SPECTRA	ISSC SPECTRA GP128
NORTH ATLANTIC EXCEEDANCE	1351400	1516000	1340200
MID ATLANTIC EXCEEDANCE	1352000	1519000	1346000
NORTH PACIFIC EXCEEDANCE	1421200	1574000	1433000

VLCC

	HINDCAST SPECTRA GP128	STATION INDIA SPECTRA	ISSC SPECTRA GP128
NORTH ATLANTIC EXCEEDANCE	2510000	2702300	2377000
MID ATLANTIC EXCEEDANCE	2520000	2706000	2381200
NORTH PACIFIC EXCEEDANCE	2688300	2809000	2462000

87,000 DWT TANKER

	HINDCAST SPECTRA GP128	STATION INDIA SPECTRA	ISSC SPECTRA GP128
NORTH ATLANTIC EXCEEDANCE	1554000	1713000	1489000
MID ATLANTIC EXCEEDANCE	1560100	1717300	1490000
NORTH PACIFIC EXCEEDANCE	1651000	1779000	1538200

GENERAL CARGO SHIP

	HINDCAST SPECTRA GP128	STATION INDIA SPECTRA	ISSC SPECTRA GP128
NORTH ATLANTIC EXCEEDANCE	163900	185100	161400
MID ATLANTIC EXCEEDANCE	162600	184200	156720
NORTH PACIFIC EXCEEDANCE	166920	189440	164000

ATTACHMENT C

Index to Appendices

APPENDIX 1

Part 1 of 6

SL-7 CONTAINERSHIP

Roll Displacement
Vertical Bending Moment Amidships
Vertical Shear Force Amidships
Vertical Acceleration - Bow
Vertical Acceleration - 0.2L aft of FP
Vertical Acceleration - Amidships
Lateral Acceleration - Amidships

Response for hindcast grid point
(Equal probability of Heading)

G272S7
G275S7
G278S7
G187S9

APPENDIX 1

Part 2 of 6

SL-7 CONTAINERSHIP

Roll Displacement
Vertical Bending Moment Amidships
Vertical Shear Force Amidships
Vertical Acceleration - Bow
Vertical Acceleration - 0.2L aft of FP
Vertical Acceleration - Amidships
Lateral Acceleration - Amidships

Response for hindcast grid point
(Equal probability of Heading)

G128S9*
G105S9
G184S9

*includes slamming and shipping of water responses

APPENDIX 1

Part 3 of 6

SL-7 CONTAINERSHIP

Roll Displacement
Vertical Bending Moment Amidships
Vertical Shear Force Amidships
Vertical Acceleration - Bow
Vertical Acceleration - 0.2L aft of FP
Vertical Acceleration - Amidships
Lateral Acceleration - Amidships

Response for hindcast grid point
(Equal probability of Heading)

G181S9
G216S3
G102S3

APPENDIX 1

Part 4 of 6

SL-7 CONTAINERSHIP

Roll Displacement
Vertical Bending Moment Amidships
Vertical Shear Force Amidships
Vertical Acceleration - Bow
Vertical Acceleration - 0.2L aft of FP
Vertical Acceleration - Amidships
Lateral Acceleration - Amidships

Response for hindcast grid point
(Equal probability of Heading)

G056S3
G045S2*
G114S2

*includes slamming and shipping of water responses

APPENDIX 1

Part 5 of 6

SL-7 CONTAINERSHIP

Roll Displacement
Vertical Bending Moment Amidships
Vertical Shear Force Amidships
Vertical Acceleration - Bow
Vertical Acceleration - 0.2L aft of FP
Vertical Acceleration - Amidships
Lateral Acceleration - Amidships

G128S9 (ATLANTIC) Hindcast Spectra

Speeds - 0, 10, 20, 25, 30 knots

Headings - 0, 30, 60, 90, 120, 150, 180 degrees

APPENDIX 1

Part 6 of 6

SL-7 CONTAINERSHIP

Roll Displacement
Vertical Bending Moment Amidships
Vertical Shear Force Amidships
Vertical Acceleration - Bow
Vertical Acceleration - 0.2L aft of FP
Vertical Acceleration - Amidships
Lateral Acceleration - Amidships

G045S2 (PACIFIC) Hindcast Spectra

Speeds - 0, 10, 20, 25, 30 knots

Headings - 0, 30, 60, 90, 120, 150, 180 degrees

APPENDIX 2

Part 1 of 2

V.L.C.C.

Roll Displacement
Vertical Bending Moment Amidships
Vertical Shear Force Amidships
Vertical Acceleration - Bow
Lateral Acceleration - Bridge

Responses for hindcast grid points
(Equal probability of Heading)

G272S7
G275S7
G278S7
G187S9
G128S9*
G105S9
G184S9

*includes slamming and shipping of water responses

APPENDIX 2

Part 2 of 2

V.L.C.C.

Roll Displacement
Vertical Bending Moment Amidships
Vertical Shear Force Amidships
Vertical Acceleration - Bow
Lateral Acceleration - Bridge

Responses for hindcast grid points
(Equal probability of Heading)

G181S9
G216S3
G102S3
G056S3
G045S2*
G114S2

*includes slamming and shipping of water responses

APPENDIX 3

Part 1 of 2

87,000 DWT TANKER

Roll Displacement
Vertical Bending Moment Amidships
Vertical Shear Force Amidships
Vertical Acceleration - Bow
Lateral Acceleration - Bridge

Response for hindcast grid points
(Equal probability of Heading)

G272S7
G275S7
G278S7
G187S9
G128S9*
G105S9
G184S9

*includes slamming and shipping of water responses.

APPENDIX 3

Part 2 of 2

87,000 DWT TANKER

Roll Displacement
Vertical Bending Moment Amidships
Vertical Shear Force Amidships
Vertical Acceleration - Bow
Lateral Acceleration - Bridge

Response for hindcast grid points
(Equal probability of Heading)

G181S9
G216S3
G102S3
G056S3
G045S2*
G114S2

*includes slamming and shipping of water responses.

APPENDIX 4

Part 1 of 2

GENERAL CARGO SHIP

Roll Displacement
Vertical Bending Moment Amidships
Vertical Shear Force Amidships
Vertical Acceleration - Bow
Lateral Acceleration - Bridge

Response for hindcast grid points
(Equal probablity of Heading)

G272S7
G275S7
G278S7
G187S9
G128S9*
G105S9
G184S9

*includes slamming and shipping of water responses.

APPENDIX 4

Part 2 of 2

GENERAL CARGO SHIP

Roll Displacement
Vertical Bending Moment Amidships
Vertical Shear Force Amidships
Vertical Acceleration - Bow
Lateral Acceleration - Bridge

Response for hindcast grid points
(Equal probability of Heading)

G181S9
G216S3
G102S3
G056S3
G045S2*
G114S2

*includes slamming and shipping of water responses.

APPENDIX 5

Part 1 of 4

SL-7 CONTAINERSHIP

Roll Displacement
Vertical Bending Moment Amidships
Vertical Shear Force Amidships
Vertical Acceleration - Bow
Lateral Acceleration - Amidships

Hindcast Grid Point G128S9
Measured - Station INDIA

Hindcast Spectra	Hindcast Exceedance
Hindcast Spectra	Measured Exceedance
Hindcast Spectra	Observed Exceedance
Measured Spectra	Hindcast Exceedance
Measured Spectra	Measured Exceedance
Measured Spectra	Observed Exceedance
ISSC Spectra	Hindcast Exceedance
ISSC Spectra	Measured Exceedance
ISSC Spectra	Observed Exceedance

APPENDIX 5

Part 2 of 4

V.L.C.C.

Roll Displacement
Vertical Bending Moment Amidships
Vertical Shear Force Amidships
Vertical Acceleration - Bow
Lateral Acceleration - Amidships

Hindcast Grid Point G128S9
Measured - Station INDIA

Hindcast Spectra	Hindcast Exceedance
Hindcast Spectra	Measured Exceedance
Hindcast Spectra	Observed Exceedance
Measured Spectra	Hindcast Exceedance
Measured Spectra	Measured Exceedance
Measured Spectra	Observed Exceedance
ISSC Spectra	Hindcast Exceedance
ISSC Spectra	Measured Exceedance
ISSC Spectra	Observed Exceedance

APPENDIX 5

Part 3 of 4

87,000 DWT TANKER

Roll Displacement
Vertical Bending Moment Amidships
Vertical Shear Force Amidships
Vertical Acceleration - Bow
Lateral Acceleration - Amidships

Hindcast Grid Point G128S9
Measured - Station INDIA

Hindcast Spectra	Hindcast Exceedance
Hindcast Spectra	Measured Exceedance
Hindcast Spectra	Observed Exceedance
Measured Spectra	Hindcast Exceedance
Measured Spectra	Measured Exceedance
Measured Spectra	Observed Exceedance
ISSC Spectra	Hindcast Exceedance
ISSC Spectra	Measured Exceedance
ISSC Spectra	Observed Exceedance

APPENDIX 5

Part 4 of 4

GENERAL CARGO SHIP

Roll Displacement
Vertical Bending Moment Amidships
Vertical Shear Force Amidships
Vertical Acceleration - Bow
Lateral Acceleration - Amidships

Hindcast Grid Point G128S9
Measured - Station INDIA

Hindcast Spectra	Hindcast Exceedance
Hindcast Spectra	Measured Exceedance
Hindcast Spectra	Observed Exceedance
Measured Spectra	Hindcast Exceedance
Measured Spectra	Measured Exceedance
Measured Spectra	Observed Exceedance
ISSC Spectra	Hindcast Exceedance
ISSC Spectra	Measured Exceedance
ISSC Spectra	Observed Exceedance

APPENDIX 6

VERTICAL BENDING MOMENT AMIDSHIPS

SL-7 Containership
V.L.C.C.
87,000 DWT Tanker
General Cargo Ship

Hindcast Spectra	N. Atlantic Exceedance
Hindcast Spectra	Mid-Atlantic Exceedance
Hindcast Spectra	N. Pacific Exceedance
Measured Spectra	N. Atlantic Exceedance
Measured Spectra	Mid-Atlantic Exceedance
Measured Spectra	N. Pacific Exceedance
ISSC Spectra	N. Atlantic Exceedance
ISSC Spectra	Mid-Atlantic Exceedance
ISSC Spectra	N. Pacific Exceedance

END

FILMED

11-85

DTIC